Ana Crespo Solana
Filipe Castro
Nigel Nayling *Editors*

Heritage and the Sea

Volume 2: Maritime History and Archaeology of the Global Iberian World (15th-18th centuries)

Springer

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Preface

At the core of this book, a collection of chapters from a diverse range of authors, is a desire to draw on a wide array of perspectives and disciplinary approaches to renew our understanding and appreciation of Iberian maritime heritage of the Early Modern Period. Its catalyst is the ForSEAdiscovery Project – a multi-disciplinary endeavour which brought together established and emerging researchers to investigate Iberian shipbuilding and particularly its relationship to forests and timber supply through the lenses of archaeology, history and earth sciences. Many of the chapters draw directly on the project's research results. Other chapters come from collaborations and research associations beyond and encouraged by ForSEAdiscovery.

Our hope is that this collection will be of interest to scientists, academics and students of history and archaeology in the broadest sense, but also accessible to a broad audience seeking a current overview of research into the phenomenon of Iberian seafaring during a period of technological and social transformation. A period in which European horizons expanded to encompass global dimensions through maritime enterprise. Our ambition has been to seek and present new insights and research directions particularly through multi-disciplinary collaboration.

We owe a debt of gratitude to a wider research community than solely the contributors to this collection. To our ForSEAdiscovery family: Aoife Daly, Ute Sass-Klaassen, Jan Willem Veluwenkamp, Ignacio García González, Tomasz Wazny, Garry Momber, Christin Heamagi, Brandon Mason, and so many other members of the ForSEAdiscovery consortium, colleagues and friends who accompanied us in this incessant search for answers in the forest and in the sea of the history of the Iberian empires.

We dedicate this book to our beloved Fadi, lost to us too young, always in our hearts.

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Chapter 1
Dendroarchaeology of Shipwrecks in the Iberian Peninsula: 10 Years of Research and Advances

Marta Domínguez-Delmás, Sara A. Rich, and Nigel Nayling

Abstract In the Iberian Peninsula, tree-ring research on shipwrecks started in the 2000s by the authors with the aims of identifying shipwrecks as Atlantic–Iberian-built vessels, studying the organization of timber supply, and refining our understanding of the development of shipbuilding along the Iberian–Atlantic coast during the Early Modern Period. This article compiles the results and observations gathered in the period 2009–2019 through dendrochronological analysis of 23 shipwreck assemblages found in the Iberian Peninsula and elsewhere. Only three of these shipwrecks (*Triunfante*, *Magdalena*, and *Bayonnaise*) had been previously identified and had a known ship history, including date and location of construction. The rest (Barceloneta I, Newport, Ribadeo, San Sebastián, Matagrana, Punta Restelos, Arade 1, Ria de Aveiro F and G, Barreiros, Belinho 1, Delta I, II, and III, Cee 1 and 2, Yarmouth Roads, Emmanuel Point II and III, and Highbourne Cay) had less precise dating based on historical information, construction features, archaeological context/artifacts, and/or radiocarbon dates. Our results demonstrate an almost-exclusive use of deciduous oak (*Quercus* subg. *Quercus*) in structural hull elements until the mid-eighteenth century and suggest a transition from differentiated selection of trees based on growth rates in the fifteenth century toward an indifferent selection in subsequent centuries due to technological advances. Our findings are discussed in the context of shipbuilding and seafaring in the Early Modern Period.

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1 Introduction

Dendrochronology is widely used in the North of Europe to establish the date and provenance of timbers from ship finds subjected to archaeological study. The development of extensive reference tree-ring datasets of different species in most of Europe often allows the successful dating of timber structures, including ship assemblages from Roman times (Čufar et al. 2014; Jansma et al. 2014), the Viking era (Bonde and Crumlin-Pedersen 1990; Crumlin-Pedersen and Olsen 2002; Nordeide et al. 2020), as well as from the Late Medieval, Early Modern, and Modern Period (Daly 2007; Daly and Nymoen 2008; Dobbs and Bridge 2009; Domínguez-Delmás et al. 2013; Haneca and Daly 2014; Nayling and Susperregi 2014; Läänelaid et al. 2019; Lorentzen et al. 2020). Dendrochronological research on shipwrecks and maritime sites in the Americas has also taken off in recent years (Martin-Benito et al. 2014; Creasman et al. 2015). Once the date is established, further inferences can be made about the construction period of the ship and the timber supply area, and woodworking techniques and forest management practices can be placed in an exact chronological period (Rich et al. 2018a; Domínguez-Delmás et al. 2019). In the Iberian Peninsula, tree-ring research on shipwrecks has taken great strides in the past 10 years. This chapter presents the observations and results obtained through dendrochronological research of timbers from shipwrecks found in the Iberian Peninsula, as well as Iberian shipwrecks found elsewhere (the Mediterranean and the Caribbean), predominantly in the period of 2009–2019. These shipwrecks were researched to find out whether they were built in the Iberian Peninsula and, if so, to refine our understanding of the development of shipbuilding along the Iberian–Atlantic coast during the Early Modern Period. Specific objectives were gaining knowledge about (i) their chronology, (ii) the provenance of the wood, and (iii) the procurement of timber for shipbuilding (selection of species and growth rates for particular elements in the ship). In the following, we compile the results of this research, presenting the results of each individual shipwreck, and make inferences, when possible, about the organization of the wood supply.[1] We then reflect on the lessons learned in these 10 years and discuss the results in the context of shipbuilding and seafaring in the Early Modern Period.

[1] Given the length of this chapter, we decided to present a synthesis of dendrochronological results of each shipwreck, and refer the interested reader for detailed results (e.g., graphs and statistics of internal cross-matches between samples of the same shipwreck) to the reports that have been uploaded into Zenodo or other repositories, where they are openly available.

2 Background to Dendroarchaeology of Shipwrecks in the Iberian Peninsula

In the Iberian Peninsula, dendroarchaeological studies started in the 1980s with the research of timbers from historic buildings (Richter and Eckstein 1986). Until the first decade of the twenty-first century, investigations were mostly restricted to the study of historic buildings in the northeast, center, and south of Spain (Domínguez-Delmás et al. 2015 and references therein). To initiate tree-ring studies on cultural heritage outside these regions, the project *Filling in the blanks in European dendrochronology: building a multidisciplinary research network to assess Iberian wooden cultural heritage worldwide* (also known as Iberian Heritage Project, henceforth IHP) was launched in 2009. A network of foresters, historians, nautical archaeologists, and dendrochronologists was assembled to identify old-growth forests, historic buildings with timber-framed roofs, art pieces, and shipwreck assemblages in Spain and Portugal that could be subjected to dendrochronological research (Domínguez-Delmás 2015). Through this network, the opportunity arose to examine and sample diverse groups of timbers from archaeological structures and shipwrecks at the Catalonian Centre for Underwater Archaeology (CASC) in Girona (Spain), at the Centre of Underwater Archaeology (CAS) in Cadiz (Spain), and at the former *Divisão de Arqueologia Náutica e Subaquática, Instituto de Gestão do PatrimónioArquitectónico e Arqueológico* (DANS/IGESPAR) in Lisbon (Portugal). The assemblages studied at those underwater archaeology centres between 2009 and 2011 became, together with the Newport Medieval Ship (excavated in Wales between 2002 and 2003 and identified as a Basque Country-built merchant vessel; (Nayling and Jones 2014), the first Iberian ships/wrecks being subjected to dendrochronological inquiry.

Part of the network built during the IHP subsequently launched the ForSEAdiscovery project (*Forest Resources for Iberian Empires: Ecology and Globalization in the Age of Discovery*; henceforth FSD), which ran from 2014 to 2018. This project recruited 18 fellows as researchers, who were divided into three work packages (History, Nautical archaeology, and Wood provenancing) to examine the timber supply for Iberian Empires during the Early Modern Period (Nayling and Crespo Solana 2016; Crespo Solana et al. 2018; Crespo Solana 2019). Within the FSD, we targeted Iberian shipwrecks along Atlantic–Iberian coasts, the south of England and the Caribbean, aiming to determine their exact chronology and to understand the organization of the timber supply for shipbuilding (including the selection of trees (old/young, fast/slow-grown) and species for different timber elements, forest management practices to increase timber production, timber imports, etc.).

3 Sampling Strategy and Dendrochronological Methods

Between 2009 and 2019, a total of 23 shipwrecks were inspected and sampled for dendrochronological research (Fig. 1.1; Table 1.1). In addition to these wrecks, the Newport Ship has been included in this chapter to contribute to the discussion of fifteenth-century ships. The identifications of the *Triunfante*, *Magdalena*, and *Bayonnaise* were known and well documented. The former two were both built in the Spanish royal shipyard of Esteiro (Ferrol, NW Spain) and launched in 1756 and 1773, respectively. The *Bayonnaise* was a French corvette built in Bayonne (W France) in 1794. The rest of the shipwrecks targeted have been relatively dated to different times of the Early Modern Period (fifteenth to eighteenth centuries) based on historical information, construction features, archaeological context, and/or radiocarbon dating.

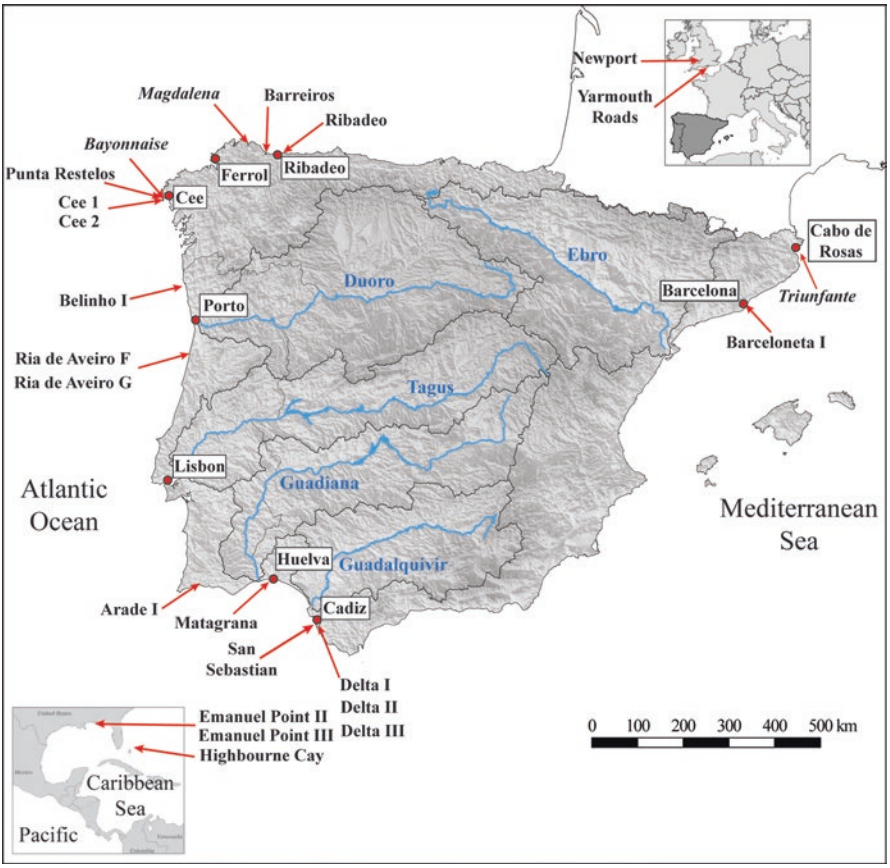

Fig. 1.1 Shipwrecks studied in the period 2009–2019 within the IHP and the FSD projects, plus the Newport Ship, indicating the location where they were found. Some cities and geographical features are indicated for additional geographical reference

Table 1.1 Number of samples collected on each shipwreck, presented with their corresponding identification of wood species when known

Shipwreck	Chronology	*Quercus* subg. *Quercus*	*Pinus sylvestris/ nigra*	*Picea abies/ Larix decidua*	*Abies alba*	Conifer	*Fagus sylvatica*	*Castanea sativa*	Tropical	Others	Total
Barceloneta I	c. 1410?	14									14
Newport	c.1450	110					1				111
Barreiros	Fifteenth century?	4								1	5
Ría de Aveiro G	Fifteenth century?	2									2
Ría de Aveiro F	Fifteenth–eighteenth century	1						1	9		11
Highbourne cay	c. 1520	16									16
Emanuel point II	c. 1550s	31									31
Emanuel point III	c. 1550s	4									4
Yarmouth roads	Mid-sixteenth century	17									17
Belinho 1	16th–eighteenth century?	12				2			1		15
Delta II	Mid-sixteenth century	35				3	2		4	5	49
Arade 1	c. 1583	24						2			26
Punta Restelos	c. 1590s	7									7
Ribadeo	c. 1590s	36	2	3	2	1	1	2		1	48
Delta I	Seventeenth century	22	3				1				26
Delta III	Seventeenth century	6	1				2				9
Matagrana	17th–eighteenth century	2									2
Triunfante	1754/56		6								6
Magdalena	1778	17	4			1					22
San Sebastian	Eighteenth century?	2									2
Bayonnaise	Eighteenth century	10									10
Cee 1	Late nineteenth century	5				1					6
Cee 2	?	3									3
		380	16	3	2	8	7	5	14	7	442

Some of those samples were collected for wood identification only, or to have an idea of the growth rate of the tree furnishing the timber. Therefore, the total number does not represent the number of samples selected for dendrochronological research

Given the objectives of the research, which included the characterization of trees used during the Early Modern Period for shipbuilding, the sampling strategy avoided bias toward timbers suitable for dendrochronological dating (i.e., containing more than 80 tree rings). Therefore, samples with as little as 15–30 rings were also selected for tree-ring analysis in order to acquire growth rates of the trees used for specific elements of the ship. For some shipwrecks (*Triunfante*, Ribadeo, Yarmouth Roads, and *Bayonnaise*) preliminary wood identification and ring counts were carried out under water directly on some of the timbers (Fig. 1.2a, b) to have an estimation of tree species used and tree ages without having to saw off samples from all the timbers.

The collection of samples was carried out under different circumstances and followed, when possible, the methods now detailed in Rich et al. (2018b) and Domínguez-Delmás et al. (2019). Most of the shipwrecks were sampled underwater (*Triunfante*, Ribadeo, San Sebastián, Delta shipwrecks, Yarmouth Roads, *Magdalena*, Cee shipwrecks, *Bayonnaise*, Highbourne Cay, and Emanuel Point), whereas the Matagrana and Barreiros were sampled in an intertidal zone. Waterlogged timbers from the Newport Ship, Arade 1, Ría de Aveiro F and G, and Belinho 1 shipwrecks were sampled on land at different conservation facilities, before undergoing conservation treatment (Fig. 1.2c). In all these cases, samples for dendrochronological research (cross-sections) were removed with a handsaw from the selected structural timbers, as well as from some cargo elements (in the cases of the Ribadeo and the Delta II) (Fig. 1.2d, e). Additionally, fragments of some timbers were also collected for wood identification and to establish whether those timbers may contain enough tree rings for following up dendrochronological research.

In the case of Barceloneta I, sampling was constrained by the fact that the wreck was going to be reassembled and displayed at the Barcelona History Museum after conservation treatment with polyethylene glycol (PEG). Therefore, sampling of timbers by sawing a cross-section was restricted to the fragments of hull planks broken when the backhoe unearthed the wreck. In two of the frames, tree-ring patterns in the notches carved to accommodate the futtocks were photographed (Fig. 1.2f, g). In this way, photographing the surface of several notches after cleaning them with razor blades and applying chalk to enhance visualization of tree rings, it was possible to register the tree-ring patterns from the pith to the outermost rings, which corresponded to the waney edge, representing the cutting year of the tree. Tree rings were also photographed on one hull plank, as the edge was quite smooth and it was possible to clean it with razor blades. Similarly, the barrel staves from the cargo of the Delta II shipwrecks were cleaned with razor blades and analyzed by means of digital photographs.

To analyze the tree rings in the sawn samples, the transverse surface of the wood was cleaned with razor blades from the inner- to the outermost ring. The presence/absence of pith and sapwood was also recorded. This manner of inspection served to identify some species that show distinct anatomical features in the transverse section, which make them distinguishable by the naked eye. Such identification is possible, for instance, for deciduous oaks (*Quercus* subg. *Quercus*), which show large earlywood vessels placed in a ring-porous disposition and large multiseriate

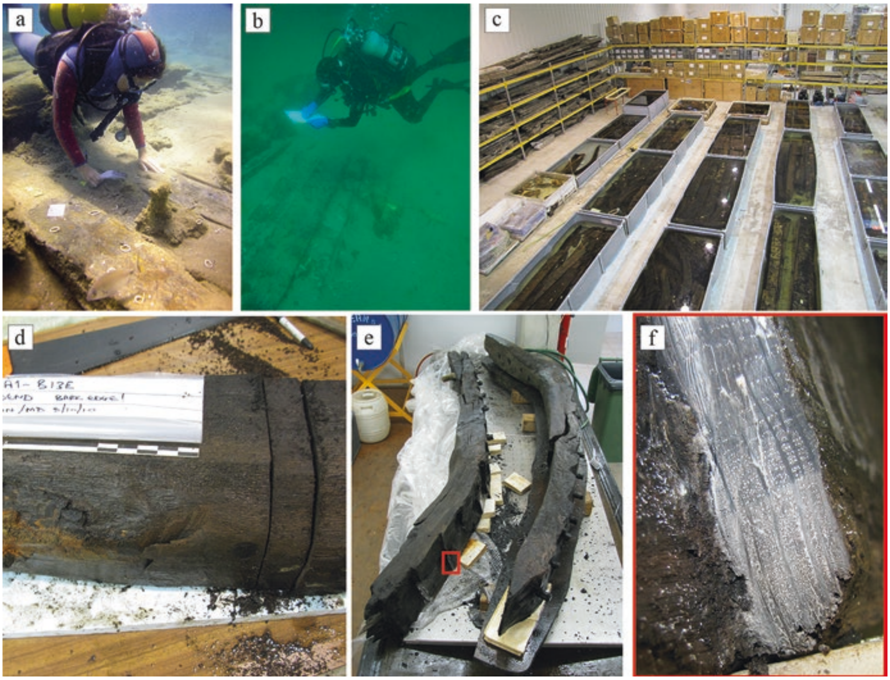

Fig. 1.2 Inspection and sampling of shipwrecks (**a**) examining *Triunfante* timbers to determine the species as oak or conifers. (Source photo: CASC archive), (**b**) underwater registration of Ribadeo timbers prior to sampling. (Photo: R. González Gallero), (**c**) facilities of the IGESPAR in Lisbon where several shipwrecks were inspected and sampled, (**d**) framing timber of the Arade 1 sawn where complete sapwood was present, (**e** and **f**) joggle on framing timbers of Barceloneta shipwreck where tree rings were recorded after cleaning with razor blades and applying chalk powder to enhance the visibility of the tree rings. (Photos **c**–**f**: M. Domínguez-Delmás)

medullary rays; chestnut (*Castanea sativa*), which is very similar to the group of deciduous oaks but lacks the multiseriate medullary rays; beech, ash, etc. (see Schweingruber 1990 for a detailed description of the wood anatomy of those species). The identification of species that cannot be distinguished by the naked eye was done by cutting cube-shaped subsamples of approximately 1 cm^3. Then, thin slices were manually cut with razor blades from the transverse, radial, and tangential sections of the subsamples, in order to observe the micro-characteristics of the wood anatomy of each sample (see http://www.woodanatomy.ch/micro.html Schoch et al. 2004). Transmitted-light microscopes (Zeiss Axioscope40 or Olympus BX40) coupled with a digital camera (Zeiss AxioCam MRc5) were used to visualize and photograph the key anatomical features of each sample. Identifications were made using the keys proposed by Schweingruber (1990)**,** García Esteban et al. (2003), or, in the case of tropical woods, the following online resources: Wood Anatomy of European Species (http://www.woodanatomy.ch/micro.html Schoch et al. 2004) and the Inside Wood database (http://insidewood.lib.ncsu.edu/search Wheeler 2011).

Tree rings were measured in selected samples with a TimeTable measuring device (University of Vienna) coupled with PAST4 software v.4.3.1025 (SCIEM). When samples could not be taken and the research was done through photography, tree rings were photographed with a macro lens using a Sony compact camera on macro mode, and ring widths were measured on screen with CooRecorder (Cybis). The photographs included a ruler to allow the calibration of the measurements. Therefore, the obtained ring widths represent absolute values.

Crossdating between the samples and with reference chronologies was also done with PAST4. To identify potential dates, Student's *t*-values were considered after modifying the data according to Baillie and Pilcher (1973), in combination with the percentage of parallel variation (%PV) (Eckstein and Bauch 1969) and its associated significance (*p*).

4 The Shipwrecks: History, Archaeology, and Results of Dendrochronological Research

The ship finds are presented in approximately chronological order (date of construction) based on a combination of historical and archaeological information including, where relevant, scientific dating by radiocarbon and/or dendrochronology.

4.1 Barceloneta I

The Barceloneta I shipwreck was found in 2008 during development works in the eponymous coastal district of Barcelona (Spain) (Fig. 1.4a). It represents the first archaeological discovery of a clinker-built ship on the Spanish Mediterranean coast. Considering the radiocarbon dates (calibrated at two sigma) of 1310–1440 obtained for the moss found in the ship's hull, the radiocarbon date of 1395 cal CE (maximum probability) obtained for the sediments underlying the wreck, and the *ante quem* date of 1439, when the construction of a harbour dock favoured the intrusion of sand that covered the shipwreck, a possible construction date around the 1410s seems plausible (Soberón et al. 2012, p. 419).

The dismantled shipwreck was transported to the CASC, where Marta Domínguez-Delmás carried out the inspection and sampling. A total of 14 timbers were inspected and identified as deciduous oak (*Quercus* subg. *Quercus*) (Table 1.2). Cross-sections were sawn from nine plank fragments that had been damaged during the excavation on the development site. Five other elements (one hull plank, three frames, and a beam/wale) were photographed on the transverse surface after cleaning with razor blades and applying chalk.

Results showed that the hull planks had been converted radially from the parent trees' trunks, and the samples contained between 85 and 168 tree rings (Domínguez-Delmás 2009). They all lacked pith and sapwood. In contrast, framing timbers had

Table 1.2 Results of dendrochronological research of the Barceloneta I shipwreck

Sample code	Timber element	Dendro code	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
BM-T5A	Hull plank	SBS00011 SBS00012	75 69	– –	0 0	–	1.24	0.37
BM-TSN-E	Hull plank	SBS00020	100	–	0	–	1.03	0.42
BM-TSN-H	Hull plank	SBS00030	88	–	0	–	1.12	0.32
BM-TSN-I	Hull plank	SBS00040	112	–	0	–	1.30	0.37
BM-TSN-K	Hull plank	SBS00050	93	–	0	–	1.06	0.23
BM-TSN-L	Hull plank	SBS00060	166	–	0	–	0.68	0.36
BM-TSN-M	Hull plank	SBS00070	124	–	0	–	1.79	0.76
BM-TSN-N	Hull plank	SBS00080	95	–	0	–	1.24	0.36
BM-TSN-O	Hull plank	SBS00090	85	–	0	–	1.18	0.36
BM-T10A	Hull plank	SBS00100	168	–	0	–	1.31	0.37
BM-PL	Beam/Wale?	SBS00110	37	+	7	3 ± 2	4.25	1.51
BM-Q9	Framing	SBS00120	69	+	22	3 ± 2	5.55	3.01
BM-Q10A	Framing	SBS00130	64	+	25	2 ± 1	3.67	2.57
BM-Q11	Framing	–	29	+	12	LW		

All samples were oak (*Quercus* subg. *Quercus*); N: number of rings; Pith: present (+)/absent (−); SR: sapwood rings; Bark edge: absent (−), estimated number of rings till bark edge (n ± n), latewood present in last ring (LW); MRW: mean ring width; σ: standard deviation

pith and sapwood, even bark edge, allowing an estimation of the age of the trees at around 30 years (BM-Q11, which showed a regular growth pattern) and 80 years (BM-Q9 and BM0Q10A, which showed severe growth reductions). Although there is an important difference in the age of the trees used for framing timbers, their dimensions are very similar, which indicates that the trees were selected based on diameter and shape. This implies that there was a differentiated selection of trees for hull planks (slow-grown, straight-grained oaks) and for framing timbers (fast-grown trees with appropriate curvature; Fig. 1.1e).

Internal crossdating revealed that some samples from hull planks corresponded to the same element, allowing us to refit pieces that broke during the excavation (Domínguez-Delmás 2009). Furthermore, good matches were also found between two sets of hull planks and between two frames, suggesting that the wood originates from the same forest. Attempts at cross-matching these series with reference chronologies and other contemporary shipwrecks have yet to be successful.

4.2 Newport Ship

This clinker-built ship was excavated in the midst of development in this Welsh port in 2002–2003 (Nayling and Jones 2014). Tree-ring dating of a timber structure (constructed from local timber), onto which the ship had been maneuvered, provides a *terminus post quem* for the ship's arrival during spring of 1468 CE. Thousands of individual timbers were recovered for detailed documentation. The recovered

Table 1.3 Summary of Newport Ship timbers by major type

Timber type	Number	Ring count	Dendrochronology samples
Keel	1	0	1
Planks	820 (373)	440	50
Framing	524 (211)	123	32
Fillers	56	34	6
Ceiling	181	51	2
Chock/buttress	22	0	1
Bilge boards	72	41	6
Repairs/refits			
Riders	4	1	2
F10 block	1	0	1
Tingles	18	18	10
Total	939	708	111

Number of recovered pieces (number of discrete timbers in brackets), number for which ring counts and/or average ring widths collected, and number of dendrochronology samples analyzed

timbers were, where possible, assessed for species, annual ring counts, and mean ring widths by Nigel Nayling (Table 1.3). These data were collected to inform our understanding of timber selection and usage in the ship's construction and subsequent repair and alteration as well as informing a sampling strategy for full dendrochronological analysis. Tree-ring dating of a well-replicated oak ring-width mean for the clinker planking of the ship against Basque oak ring-width chronologies provided a precise date for the ship's construction (1449++CE) and provenance (Nayling and Susperregi 2014). In addition to the article publication or the dendrochronological dating of the ship's hull planks, further details are provided in a specialist report and datasets are available in the Archaeology Data Service (Nayling 2013; Nayling and Jones 2017).

The planks were normally radially split from straight-grained trees with minimal knotting. In some cases, trimmed side branches, encapsulated by later tree growth indicate forestry management (Fig. 1.3). Occasional planks exhibited the normally straight grain curving away from the long axis of the plank at one end, suggesting proximity of the crown or root of the parent tree. The age of the parent trees when felled cannot be determined with total confidence due to secondary working after initial splitting of the timber, removing the feather edge in the vicinity of the pith and the bark and some, if not all, of the sapwood from the outer edge. The majority of planks were converted from parent trees more than 100 years old, with many retaining over 140 annual rings. Marked growth trends, with a distinct transition from relatively fast growth (wide rings) to relatively slow growth (narrow rings), were common, suggesting many parent trees had begun growth in relatively open conditions before coming into competition with neighboring trees in an increasingly closed woodland environment (Nayling and Jones 2014, pp. 249–252). The data on age and growth rates are presented graphically in the Discussion (Fig. 1.5) based on a combination of ring counts and dendrochronological analysis of 339 of the 373

Fig. 1.3 Inboard face of Newport Ship hull plank 766 showing pruned side branch encapsulated in later tree growth. A rare example of direct proof of woodland management. (Photo Newport Museum and Heritage Service)

planks recovered. Care needs to be taken in interpreting scatter plots of this type of data. The samples with relatively fast growth rates and low ring counts usually reflect secondary working where radial splits have been cross-split to provide two or more planks from a single radius. Something of the organization of construction is hinted at by the identification of planks from common parent trees (through use of correlation statistics and close visual matching of growth patterns) in three pairs of planks and a further two groups of three planks. As in the case of the Barreiros wreck (below), cross-matching of tree-ring sequences from disturbed portside planking (fifth and tenth strakes) allowed this detached section to be rejoined to the main, coherent section of hull (Nayling and Susperregi 2014, p. 282).

Analysis of 128 framing timbers (floors and futtocks) indicates exclusive use of oak, carefully converted from trees (often consisting of the main stem and a large side branch in the case of floors) with natural curvature closely matching the hull curvature. Ring counts and growth rates were highly variable ranging from 40 to 157 rings (average 58 years) and 1.1 to 7.6 mm/yr (average 2.9), respectively. Eighty-one percent of these timbers retained at least partial sapwood with 16% having surviving bark (waney) edge. As ever, translating these data into parent tree figures is not straightforward. Even where the pith of the tree is present and there is complete sapwood, many of these samples probably come from branches of lower

Fig. 1.4 Some of the shipwrecks researched between 2009 and 2019 (**a**) Barceloneta. (Photo courtesy of Mikel Soberon, CODEX Arqueologia i Patrimoni), (**b**) Barreiros shipwreck at its most exposed. (Photo courtesy of Luis Ángel García), (**c**) Matagrana shipwreck. (Photo IAPH archive), (**d**) close view of *Triunfante*. (Photo CASC archive)

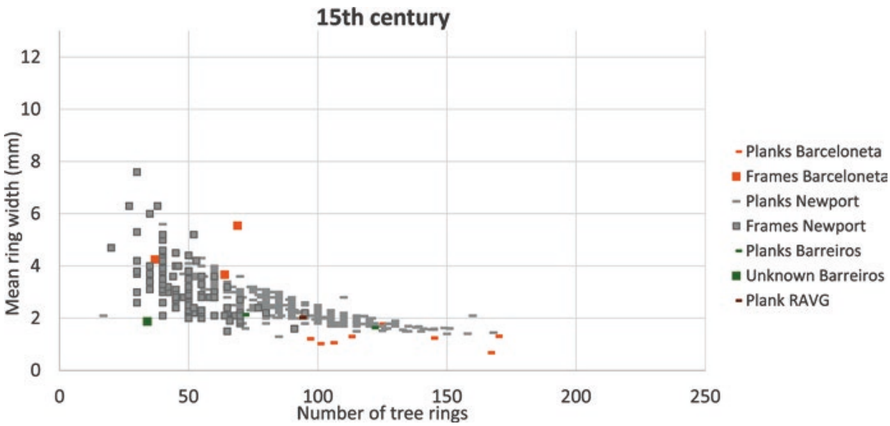

Fig. 1.5 Scatter plot of mean ring width against ring count for studied oak timber assemblages for the medieval (known or suspected fifteenth century) Iberian ships of Barceloneta I, Newport, and Barreiros

age and different growth rates to the stem of the parent tree. Nonetheless, it is evident that the framing timbers were derived from a different group or groups of trees than the planks. None of the ring-width sequences from the framing timbers matched against those of the planks, only a small proportion of them could be cross-matched against each other, and the mean of these series could not be matched against previously dated chronologies or site masters in Spain (or elsewhere). Until we can radically expand the temporal and geographical replication of oak ring width in Cantabric Spain, especially to coastal areas from which compass timber for framing in particular was probably sourced, then ring-width dendrochronology alone is unlikely to provide absolute dating.

Ring-width data (ring counts and average ring widths) were collected from 19 stringers, but none were subjected to full dendrochronological analysis (ring-width measurement). The timber had been sawn from whole or halved, young, fast-grown oaks. Often some sapwood survived on the timbers' corners but never the bark edge. Ring counts averaged 48 (range 29–61) and average ring width 3.6 mm per year (range 1.4–5.4 mm per year).

Lesser numbers of samples were taken from ceiling planks (mostly tangentially sawn from fast-grown oaks), bilge boards (some of which dated against the hull planks and seem to have been derived from the same source), and chocks/buttresses. Samples from repair patches (tingles), and presumed refit timbers including knees and riders dated against British ring-width chronologies, especially from location such as Gloucestershire near the Severn Estuary where the ship was uncovered.

4.3 Barreiros

The Barreiros wreck was uncovered by storms in February or early March 2015 in the intertidal zone of Remior beach near Barreiros, Galicia (NW Spain) (Fig. 1.4b). A substantial section of coherent hull structure was only briefly exposed and, by the time commissioned archaeologists from Zeta Arqueoloxía could visit the site, far less was exposed and available for sampling (Nodar Nodar 2015). The archaeologist of Zeta Arqueoloxía observed that most of the elements were loose boards with negatives of round-section metal nails and a square-head imprint in the wood (some also with a round head, and apparently square section), combined in some cases with round-section treenails of c. 3 cm in diameter. They followed a pattern of two to three metal nails/one treenail (Nodar Nodar 2015). The construction characteristics observed in the preliminary inspection of the wreck pointed to a clinker-built ship, possibly from the fifteenth century or later.

Two hull planks, a floor timber, a treenail, and another timber of unknown function were sampled on site by the archaeologists and sent to the dendrochronology laboratory of the University of Santiago de Compostela, Lugo (Spain).

The four structural timbers sampled were made of deciduous oak (*Quercus* subg. *Quercus*) and lacked pith and sapwood (Table 1.4). However, the treenail was identified as willow (*Salix* spp.). The two hull planks were radially converted and

Table 1.4 Results of dendrochronological research of the Barreiros shipwreck

Sample code	Timber element	Dendro code	Species	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
MU01	Hull plank	S0020010	1	71	–	0	–	2.14	0.65
MU02	Treenail	Invalid	2	Ca. 5	+	n.a.	–	–	–
MU03	Hull plank	Invalid	1	25	–	0	–	–	–
MU04	Hull plank	S0020020	1	121	–	0	–	1.65	0.48
MU05a	Floor timber?	S0030031	1	34	–	0	–	1.88	0.41
MU05b		Fragmented; invalid		32	–	0	–	–	–

Adapted from Dominguez-Delmás and García-González (2015f)
Species: *1*, *Quercus* subg. *Quercus*; *2*, *Salix* spp.; N: number of rings; Pith: present (+)/absent (−); SR: sapwood rings; n.a.: not applicable; Bark edge: absent (−); MRW: mean ring width; σ: standard deviation

contain 71 and 121 rings, respectively. MU03 was discarded for dendrochronological investigation because it had only 25 rings. MU05 consists of two different wooden elements, and while they all contained insufficient rings for dendrochronological dating, only one piece (a) (with 34 rings) was included in the research to evaluate its synchronization with the hull planks.

The series obtained from the hull planks do not show a clear synchronization between them. However, the short series obtained from sample MU05a shows an outstanding match with hull plank MU04 (Domínguez-Delmás and García-González 2015f). Crossdating with reference chronologies and with data from potentially contemporary shipwrecks (Barceloneta I and Newport) did not result in a conclusive match.

4.4 Ria de Aveiro G

This shipwreck was located in 2003 following dredging works carried out in connection with the construction of the solid bulk terminal at the Port of Aveiro, Portugal. The disturbed remains comprised a clinker-built ship dated by radiocarbon to 1290–1440 calibrated to two sigma (Bettencourt 2009).

In 2010, timbers held in store were examined at the former *Divisão de Arqueologia Náutica e Subaquática, Instituto de Gestão do Património Arquitectónico e Arqueológico* (DANS/IGESPAR) in Lisbon. Of the dozens of fragments of oak framing and radially converted planks examined, only two plank fragments had more than 50 rings and were sampled. The ring-width series of the two samples exhibited an outstanding visual and statistical match between them indicating that the timbers derived from the same parent tree, or that the fragments sampled originated from the same timber (Table 1.5). Crossdating with reference chronologies did not provide a match. Therefore, these samples remain undated.

Table 1.5 Results of dendrochronological research of the Ria de Aveiro G shipwreck

Sample code	Timber element	Dendro code	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
GR1–006	Plank	PRAG0010	81	–	0	–	2.14	0.97
GR1–008	Plank	PRAG0021	93	–	0	–	1.93	0.91
GR1-6_8	Plank	PRAG_1-2T	93	–	0	–	2.03	0.92

Adapted from Domínguez-Delmás (2010a)
All samples were oak (*Quercus* subg. *Quercus*); N: number of rings; Pith: absent (−); SR: sapwood rings; Bark edge: absent (−); MRW: mean ring width; σ: standard deviation

4.5 Ria de Aveiro F

The Ria de Aveiro F site was identified in 2002 during dredging of the port of Aveiro in Portugal (Lopes et al. 2020). Radiocarbon analyses of wood samples from the scattered remains of at least two vessels (an oak carvel-built vessel with parallels with Ibero-Atlantic ships and a clinker-built boat) gave date ranges of 1280–1420 CE and 1320–1350; 1390–1460 CE, respectively (95% probability at two sigma, see Lopes et al. 2020 Table 2). Recent reanalysis of these assemblages by Lopes et al. (2020) has questioned the usefulness of these radiocarbon dates. Investigations of the construction methods and materials suggest that the carvel-built ship, with some Mediterranean and some Atlantic features, was engaged in the transatlantic trade in the early sixteenth century. The smaller clinker-built boat, which was perhaps a skiff used to support the main carvel-built ship, was made from tropical wood which strengthens the conclusion that the carvel-built Aveiro F shipwreck had been engaged in the transatlantic trade.

In 2010, timbers from the Ria de Aveiro F shipwreck stored at the facilities of the *Divisão de Arqueologia Náutica e Subaquática, Instituto de Gestão do Património Arquitectónico e Arqueológico* (DANS/IGESPAR) in Lisbon, were inspected by Nigel Nayling and Marta Domínguez-Delmás. Through visual observation of several planks from this wreck, it was immediately concluded that they were of some diffuse porous species, i.e., with pores or small vessels distributed across the entire ring width (Schweingruber 1990). We decided to sample some of those planks, together with smaller fragments from other elements, to identify their species and assess their suitability for dendrochronological research. To this end, cross-sections were manually sawn from one end on nine planks. Smaller fragments of approximately 2 cm^3 were taken from two other elements, and a cross-section was cut from a barrel stave that had been found associated with the shipwreck remains.

The barrel stave was found to be made out of chestnut (*Castanea sativa*), whereas the sample from an element that seemed to be made out of branch wood was identified as deciduous oak (*Quercus* subg. *Quercus*) (Table 1.6). Chestnut is commonly spread in Europe, whereas different species of deciduous oaks can be found in Europe and North America.

Table 1.6 List of sampled timbers

Sample code	Description	Wood type	Observations
RAVF 31	Branchwood framing timber Carvel-built vessel	Deciduous oak	Ring porous (tr) Multiseriate medullary rays (tr, tg) Flame-like pore groupings in latewood (tr) 15 rings, no sapwood, no pith
RAVF stave	Barrel stave	Chestnut	Ring porous (tr) Uniseriate rays (tr, tg) Flame-like pore groupings in latewood (tr) Ca. 5 rings
RAVF 258	Hull plank (clinker), tangential	–	Not possible to identify; the subsample was too small and hard to prepare proper micro-slices
RAVF S/R 01	Hull plank (clinker), tangential	Tropical	Diffuse porous Marginal parenchyma bands not convincing One raw of upright cells in the rays (rd)
RAVF 115	Hull plank (clinker), tangential	Tropical	Diffuse porous One raw of upright cells in the rays (rd)
RAVF 353	Hull plank (clinker), tangential	Tropical	Diffuse porous One raw of upright cells in the rays (rd)
RAVF 354_10 RAVF 354_14 RAVF 354_16	Hull plank (clinker), tangential	Tropical	Abundant radially clustered vessels (x2) (tr) Oil cells apparent (rd) Vessel ray pits big and simple Plenty of septate fibers Oil cells present
RAVF 416	Hull plank (clinker), tangential	Tropical	Simple vessel parenchyma cells Oil cells in axial parenchyma?
RAVF 420	Hull plank (clinker), tangential	Tropical	Inter-vessel pits ca. 15 μm Oil cells present (tr) One raw of upright cells in the rays (rd) Parenchyma in bands (rd) Septate fibers present (tg) Vessel ray pits simple (rd) Vessel size ca. 100–200 μm (tr) 2/4 parenchyma strands (tr)
RAVF 3027	Tangential plank (clinker); timber from rear	Tropical	Diffuse porous One raw of upright cells in the rays (rd)

Adapted from Domínguez-Delmás, 2013 and Lopes et al. 2020, Table 1

The nine planks analyzed were determined to be from the same tropical species (see Domínguez-Delmás 2013 for details). Anatomical features found in all these samples were run in the InsideWood database, including other features that were clearly visible in some of the samples. As a result, InsideWood returned between 5 and 27 species from the taxonomic families Anacardiaceae, Lauraceae, and Myristicaceae (Table 1.7). Species of these families are present in Central and South

America, Africa, and Asia, making it extremely difficult to infer the potential construction area or the route sailed.

The most interesting information obtained from this research was the identification of planks made of tropical wood. While the difficulty of narrowing down the species when dealing with tropical wood was explained above, if most of the hull was made with tropical wood, we could infer that the ship was built in a colonial harbor in the tropics. It is vital to remember that oceangoing Iberian ships from this time had access to timbers on a global scale.

The stave made of chestnut probably originated from a barrel that served as a container for food or liquid and that was transported on the ship. The oak sample belongs to an unidentified element, which hampers the possibility of extracting much information from this piece of wood, but which also illustrates the need to compile a thorough register of all individual timbers found at underwater archaeological sites.

Table 1.7 List of species found for each search performed including different anatomical features observed in the tropical-wood samples

IAWA codes	FAMILY and species
1p, 5p, 9a, 10a, 11a, 13p, 22p, 27p, 31p, 32p, 42p, 56p, 61p, 65p, 79p, 89p, 92p, 97p, 106p, 130e, with 0 allowable mismatch	LAURACEAE Alseodaphne spp. Aniba canelilla, A. ferrea, Aniba spp. Beilschmiedia sp. MYRISTICACEAE Staudtia stipitata Warb.
1p, 5p, 9a, 10a, 11a, 13p, 22p, 27p, 31p, 32p, 42p, 56p, 61p, 65p, 79p, 92p, 97p, 106p, 130e, with 0 allowable mismatch	LAURACEAE Alseodaphne spp. Aniba canelilla, A. ferrea, A. rosaeodora Ducke, Aniba spp. Beilschmiedia sp. Endiandra spp. Phoebe posora Phoebe spp. MYRISTICACEAE Staudtia stipitata Warb.
1p, 5p, 9a, 10a, 11a, 13p, 22p, 27p, 31p, 42p, 56p, 61p, 65p, 79p, 89p, 92p, 93p, 97p, 106p, 124e, 125e, 126e, 130e, with 1 allowable mismatch	ANACARDIACEAE Comocladia spp. Mauria heterophylla Pleiogynium spp. Cryptocarya mannii MORACEAE Morus spp. MYRISTICACEAE Endocomia macrocoma Endocomia rufirachis Myristica irya Staudtia stipitata Warb.

(continued)

Table 1.7 (continued)

IAWA codes	FAMILY and species
1p, 5p, 9a, 10a, 11a, 13p, 22p, 27p, 31p, 42p, 56p, 61p, 65p, 79p, 89p, 92p, 97p, 106p, 124e, 130e, with 1 allowable mismatch	ANACARDIACEAE Comocladia spp. LAURACEAE Aiouea impressa Alseodaphne spp. Aniba affinis, A. canelilla, A. férrea, A. rosaeodora Ducke, Aniba spp. Beilschmiedia sp. Cryptocarya mannii Dehaasia spp. Endiandra spp. Licaria subgrp. Canella Licaria subgr. Guianensis Licaria subbullata Mezilaurus itauba Nectandra saligna Nothaphoebe spp. Ocotea globifera Ocotea glomerata Ocotea nigra Ocotea guianensis Ocotea schomburgkiana Persea raimondii Phoebe posora Phoebe spp. Pleurothyrium spp. Ravensara aromatica Ravensara crassifolia Ravensara ovalifolia MYRISTICACEAE Staudtia stipitata Warb.

Descriptions provided following the IAWA code (1989); p = present; a = absent; e = absent required

4.6 Highbourne Cay

The early-modern shipwreck of Highbourne Cay located next to the island of the same name in the Exumas, Bahamas has a long history of investigation (see Chap. 7, Vol. 2 for details). It was recognized as a significant early-sixteenth-century vessel in the Ibero-Atlantic tradition by Oertling (2001). As a part of the most recent campaign of excavation, examination and selective sampling of the *in situ* hull remains from a dendro-archaeological perspective was undertaken by Nigel Nayling and Miguel Adolfo Martins as part of the ForSEAdiscovery project in 2017.

The often-degraded nature of the surface of the timbers of the exposed ship's hull made in situ assessment challenging. It was clear that most of the timbers derived from relatively young and fast-grown oaks (*Quercus* subg. *Quercus*). Samples were recovered from only a limited number of timbers which might have sufficient rings

Table 1.8 Results of dendrochronological research of the Highbourne Cay shipwreck

Timber code	Timber element	Dendro code	N	Pith	SR	Bark edge	MRW (mm)
T0831	Framing	HCW26	14	+	0	–	3
T0829	Framing	HCW27	20	+	0	hs?	4.2
T0835	Framing	HCW29	41	>10	0	–	1.7
T0835	Framing	HCW30	25	>10	0	–	4.5
T0814	Framing	HCW31	31	+	14	?	4.1
T0843 (fifth floor)	Framing	HCW32	21	<5	3	–	5.0
T0824	Framing	HCW33	15	<5	8	–	6.7
Unnumbered	Framing	HCW34	30	+	3	–	3.7
T0834	Framing	HCW35	23	<5	0	–	7.6
T0832	Planks	HCW28	10	+	0	–	6.9
T0841	Plank	HCW28	16	<5	9	–	5.3
NA	Tangentially converted fast-grown oak fragment of (bilge?) board	NA	5	>10	0	–	5.8
NA	Highly eroded plank fragment. Possible TN hole slightly knotty oak	NA	18	>10	0	–	1.9
NA	Oak straight grained bilge board fragment?	NA	3	>10	0	–	7.0
NA	Oak straight grained bilge board fragment	NA	3	>10	0	–	5.0
NA	Conifer straight grained fragment	NA	14	>10	0	–	2.5

All samples were oak (*Quercus* subg. *Quercus*)
N: number of rings; Pith: present (+) absent (–) less than 5 years from pith (<5) more than 10 years from pith (>10); SR: sapwood rings; Bark edge: possible (?) absent (–) possible heartwood/sapwood boundary (hs?); MRW: mean ring width

for dendrochronological ring-width analysis or other forms of high-precision dating such as radiocarbon wiggle match or isotopic dating. Most of these samples were derived from oak framing timbers with relatively fast growth rates (Table 1.8). A group of wood fragments was located forward of the first buttress on the starboard side found within a bag with prelabeled tag from the 1986 excavations. Details of these are provided in Table 1.8 with Timber code NA. These appear to predominantly derive from oak bilge boards.

4.7 *Emanuel Point II*

In 1991, the first shipwreck associated with the Tristán de Luna y Arellano 1559 expedition was discovered in shallow waters off the Florida Coast near Pensacola (Smith 2018). The second vessel, the Emanuel Point II (EP II) shipwreck was discovered by University of West Florida (UWF) archaeologists in 2006. The excavation of this ship, and also terrestrial sites associated with the Luna expedition have been undertaken over many years as research and field training by the Department of Anthropology at UWF (Bendig 2018; Worth et al. 2020). Initially, a selection of samples excavated up to 2017 was sent to Nigel Nayling for analysis. Subsequently, he joined the field team on excavations in 2018 and undertook sampling of the EPII wreck with the assistance of experienced members of the UWF team. The site lies in very shallow water, but visibility is generally very limited/zero meaning that timber selection/location required considerable assistance from the site archaeologists with an expert knowledge of the wreck and the recording frames placed over it, and that selection could be based only on feel. Samples were hand sawn from accessible timbers with a preference for timbers with at least a partially curving cross-section profile which could indicate the presence of surviving bark edge or at least partial sapwood or the heartwood/sapwood boundary.

A total of 33 samples were analyzed comprising framing timbers (futtocks and fillers), planking (hull planks and ceiling), and two chocks (buttresses to the keelson at the point of the expanded mast step (Bendig 2018). All samples were oak (*Quercus* subg. *Quercus*) (Table 1.9). It would appear that most major timbers sampled were derived from relatively young and fast-grown oaks. Even where the growth rates are slower (<2 mm per year), the parent trees do not appear to have been very old when felled. Sample 2 from futtock 7534 had the most rings (86) with partial sapwood, no pith, and an average growth rate of 1.2 mm. The only other timbers with growth rates below 2 mm per year (chock 5336 with pith, possible bark edge, and 51 rings; sample 10 futtock 7542 with pith, bark edge, and 57 rings), even if they were converted from branches, clearly derive from relatively young oak trees. Framing timbers were converted from the whole or half of the tree's stem or branch, while the planking was tangentially sawn.

4.8 Emanuel Point III

The third shipwreck associated with the Luna expedition had only recently been discovered when Nigel Nayling joined the excavations in 2018 and only a very limited area was excavated and available for inspection and sampling. Located in even shallower water than EPII, there was sufficient visibility to allow visual inspection. Only four samples were recovered, all of which were oak (*Quercus* subg. *Quercus*). The single-hull plank sample, tangentially sawn, was from a very fast-grown oak. The three framing timber samples all derived from relatively young oaks, certainly less than 100 years old when felled, with ring sequences running from near the pith to possible or certain bark edge. Their growth rates were slow-medium (Table 1.10).

Table 1.9 Results of dendrochronological research of the Emanuel Point II shipwreck

Artifact / catalogue number	Timber element	Dendro code	N	Pith	SR	Bark edge	MRW
5336	Chock	5336	51	+	18	?	1.48
6698	Chock	6698	53	+	12	–	2.46
7422	Futtock	7422	21	–	0	–	9.12
7423	Futtock	7423	18	–	0	–	2
7424	Filler	7424	31	–	11	–	2.06
7425	Ceiling	7425	4	–	0	–	10
7426	Ceiling	7426	36	–	7	–	2.86
7427	Ceiling	7427	12	–	0	–	3.33
7428	Ceiling	7428	50	–	0	–	3.33
7430	Ceiling	7430	31	–	8	–	3.57
7431	Ceiling	7431	14	–	2	–	5
7432	Plank	7432	16	–	–	–	5.35
7433	Plank	7433	5	–	–	–	9
7533	Futtock	1	37	–	–	–	5.3
7534	Futtock	2	86	–	6	–	1.2
7535	Futtock	3	23	–	–	–	3
7536	Futtock	4	24	–	–	–	4.4
7537	Plank	5	20	–	–	–	3
7538	Futtock	6		+		+	
7539	Futtock	7	41	–	–	hs?	4.1
7540	Futtock	8	54	–	23	+	2.5
7541	Futtock	9	34	+	–	hs	4.1
7542	Futtock	10	57	+	21	+	1.4
7543	Plank	11	12	–	–	–	7.5
7544	Plank	12	27	–	8	–	4.9
7545	Plank	13	9	+	–	–	11.1
7546	Plank	14	32	+	–	–	5.3
7547	Plank	15	21	+	–	–	6.1
7548	Plank	16	45	–	–	–	4.5
7549	Filler	17		–			
7551	Plank	19	40	–	–	–	6.9
7552	Plank	20	24	–	–	–	5.4
7553	Plank	21	43	–	–	–	3.8

All samples were oak (*Quercus* subg. *Quercus*)
N: number of rings; Pith: present (+) absent (–); SR: sapwood rings; Bark edge: present (+) absent (–) possible (?) heartwood/sapwood boundary (h/s) possible heartwood/sapwood boundary (h/s?); MRW: mean ring width

Table 1.10 Results of dendrochronological research of the Emanuel Point III shipwreck

Dendro code	Timber element	N	Pith	SR	Bark edge	MRW (mm)
EP3DS22	Futtock	62	<5	31	?	0.9
EP3DS23	Futtock	42	<5	17	?	3.03
EP3DS24	Futtock	78	<5	24	+	1.53
EP3DS25	Plank	10	–	0	–	6.0

All samples were oak (*Quercus* subg. *Quercus*)
N: number of rings; Pith: less than 5 rings from pith (<5) absent (−); SR: sapwood rings; Bark edge: present (+) absent (−) possible (?); MRW: mean ring width

4.9 Yarmouth Roads

The Yarmouth Roads shipwreck, located in the Solent strait of the UK, was first excavated in the 1980s (Watson and Gale 1990). Specific construction features suggest that this could be the remains of a sixteenth–seventeenth-century merchant ship built in a Spanish shipyard.

To assess the date and provenance of some timber elements, a timber sampling campaign was carried out in 2015 by underwater archaeologists of Maritime Archaeology Trust/Maritime Archaeology Ltd. based in Southampton, UK (Rich et al. 2020). Three samples identified as deciduous oak (*Quercus* subg. *Quercus*) were collected by Sara Rich and sent for dendrochronological research to the laboratory of dendrochronology of the department of botany at the University of Santiago de Compostela. They presented an insufficient number of tree rings for dendrochronological research, but ring widths were measured nonetheless to acquire information about the growth rate of the trees selected for those specific timber elements (Domínguez-Delmás and García-González 2015e).

In 2016, another sampling campaign followed and 25 more samples were collected. All samples but one had less than 50 rings, with one sample (YAR01-023W-001S) presenting 161 rings, 15 of which were sapwood (Table 1.11).

Internal crossdating provided good matches between samples 1 and 10 (TBP = 5.11; GL = 76.4***; $r = 0.61$ for 36 rings overlap),[2] whose series were averaged into the mean curve YAR1-10M. The group of samples 6, 7, and 19 also show a good visual and statistical match between them (mean TBP = 6.72, GL = 72.9; rbar = 0.62), and their measurements have been averaged into the mean curve YAR6-7-19M. Although crossdating with reference chronologies has not resulted in the date of the samples, the internal matches indicate that the wood of those samples was sourced in the same area.

[2] TBP: Student's *t*-value adapted for dendrochronological studies by Baillie and Pilcher (1973); GL: percentage of parallel variation as defined by Eckstein and Bauch (1969), asterisks represent the signification level of GL (***, $p < 0.001$); *r*: correlation coefficient.

Table 1.11 Results of dendrochronological research of the Yarmouth Roads shipwreck

Sample code	Timber element	Dendro code	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
A-YAR01-001W-001S	Framing at bow	YAR010	47	0	0	–	3.46	1.09
A-YAR01-002W-001S	Framing at bow	YAR020	35	0	6	–	3.91	1.40
A-YAR01-003W-001S	Framing at bow	YAR030	24	0	3	–	4.05	1.05
A-YAR01-004W-001S	Plank at starboard amidships	YAR041	29	0	0	–	3.45	0.70
A-YAR01-005W-001S	Stanchion(?) at starboard side of stern	YAR050	21	+	0	–	4.11	1.89
A-YAR01-006W-001S	Plank at stern	YAR060	42	+	0	–	2.86	1.43
A-YAR01-007W-001S	Plank at stern	YAR071	41	c.10	sb	–	2.90	1.07
A-YAR01-008W-001S	Plank at stern	YAR081	15	0	0	–	5.80	2.48
A-YAR01-009W-001S	Plank at stern	YAR091	28	0	0	–	4.51	1.04
A-YAR01-010W-001S	Plank at stern	YAR100	44	+	4	–	3.17	0.75
A-YAR01-011W-001S	Frame at stern	YAR111	10	0	0	–	11.53	3.14
A-YAR01-012W-001S	Framing at stern	YAR120	22	0	0	–	5.11	1.80
A-YAR01-018W-001S	Plank at starboard amidships	YAR181	26	c.5	0	–	3.51	0.63
A-YAR01-019W-001S	Plank at starboard amidships	YAR190	44	c.5	0	–	2.57	1.14
A-YAR01-020W-001S	Plank at starboard amidships	YAR201	39	+	0	–	2.50	0.59
A-YAR01-023W-001S	Plank at starboard amidships	YAR230	161	0	15	–	0.89	0.34
A-YAR01-028W-001S	Plank at starboard amidships	YAR281	36	0	0	–	2.58	0.84

All samples were oak (*Quercus* subg. *Quercus*)
Pith: present (1)/absent (–); N: number of rings; Pith: present (+)/absent (–) approximate number of rings to pith (c.*n*); SR: sapwood rings; Bark edge: absent (–); MRW: mean ring width; *σ*: standard deviation

4.10 Belinho 1

The Belinho 1 shipwreck, initially represented by a collection of artifacts and structural ship timbers washed ashore north of Esposende, Portugal in the winter storms of 2013–2014, is presented in detail in Chapter 5, Vol. 2. That chapter is an updated version of a paper presented at the IKUWA6 conference in Fremantle, Australia and published in its conference proceedings (Martins et al. 2020). During documentation of the ship timbers by a ForSEAdiscovery team in 2015, dendro-archaeological records were made by Nigel Nayling and Miguel Martins for each of the 75 timbers recorded and 15 of them were sampled for tree-ring analysis or wood identification which was subsequently carried out by Marta Domínguez-Delmás et al. (2016).

Of the 75 timbers documented in 2015, all those which could confidently be categorized as structural ship timbers were made from oak (*Quercus* subg. *Quercus*). Of these, the ring count and average ring width of 48 timbers could be determined and are presented in Table 1.12 and the scatter diagram of sixteenth-century shipwrecks (Fig. 1.6). This table includes the ring widths and, for those samples subjected to formal dendrochronological analysis, ring variability (σ) reported. During this analysis, two oak samples (Timber numbers 13 and 24 (BEL01-013W-01S and BEL01-024W-01S)) crossdated with each other showing a strong visual and statistical match, which together with the fact that both end in the same heartwood ring, indicates that these timbers derive from the same parent tree or from trees growing

Table 1.12 Results of dendrochronological research of the Belinho 1 shipwreck

Sample code	Timber element	Notes	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
3	Plank	Radial plank fragment	24	>10	0	–	11.30	
4	Plank	Very knotty tangential plank end. Major side branch	10	–	0	–	3.00	
6	Plank	Tangential fast-grown plank	12	–	0	–	5.40	
7	Plank	Tangential fast-grown plank	35	–	0	–	6.00	
9	Plank	Radial straight grained plank fragment	50	–	0	–	1.94	0.90
11	Plank	Intermediate plank fragment	10	–	0	–	3.50	
12	Plank	Tangential plank fragment	20	>10	0	–	1.70	
13	Plank	Radial slow-grown plank with encapsulated side branch	134	+	0	–	0.71	0.43
14	Framing	Tangential frame fragment medium growth straight grained	30	–	0	–	2.70	
15	Plank	Fast-grown tangential oak plank fragment	5	>10	0	–	7.20	
16	Plank	Medium growth straight grained plank fragment	20	>10	0	–	2.00	
17	Plank		10	–	0	–	7.00	
18	Plank		4	>10	0	–	5.00	
20	Plank	Straight grained medium growth radial plank fragment	25	>10	0	–	2.00	
21	Plank		9	–	0	–	8.30	
23	Plank	Tangential to radial plank fragment	92	–	0	–	1.28	0.71
24	Plank	Radial plank fragment	128	–	0	–	1.00	0.65

(continued)

Table 1.12 (continued)

Sample code	Timber element	Notes	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
27	Framing	Tangential framing fragment	11	–	0	–	9.50	
28	Plank	Tangential plank fragment	17	–	0	–	3.60	
29	Plank	Fast-grown plank fragment	12	–	0	–	12.50	
31	Plank	Fast-grown tangential plank fragment	24	–	0	–	5.00	
32	Yframe	Two core samples taken	54	+?	0	hs?	0.60	0.27
33	Plank		8	–	0	hs?	3.70	
34	Framing	Framing fragment with stem and side branches	32	+	0	hs	4.20	
35	Framing	Very knotty framing fragment	82	+	0	hs?	2.39	1.42
36	Yframe		32	+	0	hs	3.00	
37	Yframe		24	+	0	hs?	2.40	
40	Yframe		50	+	0	hs?	4.60	
43	Yframe		18	+	0	hs	2.80	
44	Floor	Curvature closely follows grain, some knots at one end	15	+	0	–	8.30	
49	Waterway		24	–	0	–	5.00	
50	Plank	Fast-grown stealer plank	10	–	0	–	5.00	
51	Mast step		30	+	0	hs?	4.30	
52	Plank		33	–	0	–	3.30	
53	Plank	Straight grained parallel to one edge	13	–	0	–	4.60	
54	Plank		100	–	0	–	1.51	0.58
57	Plank	Straight grained	5	–	0	–	6.00	
58	Plank	Tangential plank fragment with two knots and wavey grain	14	–	0	–	2.90	
59	Plank	Straight grained until grain runs away toward upper edge. No major knots	5	–	0	–	5.00	
60	Plank	Straight grained	24	–	0	–	3.00	
61	Plank		55	–	2	–	2.45	0.90
64	Plank		5	–	0	–	6.00	
66	Plank		5	–	0	–	5.60	
67	Plank	Wavey grained plank fragment	20	–	0	–	10.50	
69	Framing	Framing fragment with cross-grain	68	–	0	–	2.62	0.77
73	Sternpost	Dendro core sample	56	–	0	hs?	1.55	0.78
74	Plank		36	–	0	–	5.70	
75	Plank		47	–	0	–	1.77	0.54

All samples were oak (*Quercus* subg. *Quercus*); N: number of rings; Pith: present (+) absent (–) number of missing rings (>*n*); SR: sapwood rings; Bark edge: present (+) absent (–) possible (?) heartwood/sapwood boundary (h/s) possible heartwood/sapwood boundary (h/s?); MRW: mean ring width; σ: standard deviation

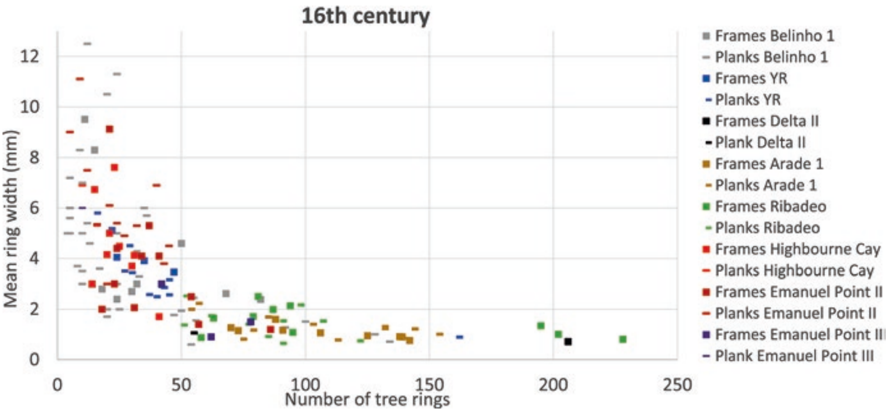

Fig. 1.6 Scatter plot of mean ring width against ring count for studied oak timber assemblages from sixteenth-century shipwrecks Belinho 1, Yarmouth Roads, Delta II, Arade 1, Ribadeo, Highbourne Cay, and Emanuel Point II and III

in the same conditions in the same area. The last ring present in those samples could represent the heartwood–sapwood border. A mean curve of 104 rings was made with both series (BEL2_4MM). The comparison of the mean curve BEL2_4MM and the other individual series between them and with European reference chronologies did not produce statistically sound results. Therefore, all samples remain for now undated.

Analysis of the ship timber assemblage indicates that many timbers were derived from relatively young oak trees. Trees with bifurcating branches were specifically chosen for the Y-frame timbers forming specialized floor timbers located toward the stern of the ship. While gauging the age of these trees at the time of felling is difficult due to the total loss of sapwood, either due to its intentional removal during woodworking or, more probably, due to postdepositional degradation and erosion, most appear to come from trees that were considerably less than 100 years old and relatively fast-grown. This is also true for the few other framing timbers where species, curvature of the parent tree, and sufficient scantling appear to have been key selection criteria. One of these (Timber 34W) had been made using the main trunk and part of a side branch to produce the required curvature of what, given the presence of a dovetail scarf, was probably a futtock (Castro et al. 2015, p. 46). The stern-knee (*coral*), timber 072W (not in table as no ring data collected), was converted from a stem and side branch at the correct acute angle. The mast step on the keelson (051W) was made using a swelling in the parent tree, probably where the main branches spread to form the crown. The majority of the planks were tangentially sawn from very fast-grown oaks. There are exceptions however. The two cross-matched plank fragments 013W and 024W could well come from the same timber, both with countersunk nail holes and one with evidence of a hood end (Castro et al. 2015, p. 100 and p. 110). The timber was radially converted from very slow-grown oak, probably over 150 years old when felled, with an encapsulated side branch reminiscent of the Newport Ship hull planks.

4.11 Delta II

The Delta II wreck was detected during work in the port area of the Bay of Cádiz, Spain. It preserved a length of 18 m and a maximum beam of 5 m. The cargo and the construction characteristics pointed to a mid-sixteenth-century Mediterranean merchant ship (Higueras-Milena and Gallardo 2016).

The archaeologists from TANIT company collected underwater some cross-sections and fragments of wood to determine the dating of the wreck and the species of different structural and cargo elements. The cargo was fully recovered, while the ship structure was documented and reburied in another part of the harbor.

A preliminary inspection of the collected fragments was carried out in 2015 by the authors (MDD) at the facilities of the Centre for Underwater Archaeology of Cádiz (CAS). The material inspected at the CAS consisted of a total of 49 samples, including structural parts of the ship, as well as individual parts of the cargo, which consisted of barrels (staves, heads, and twigs used as hoops) and chests.

Of the 49 samples inspected, 35 were oak (*Quercus* subg. *Quercus*), whereas the rest of the samples were of diverse species (Tables 1.13 and 1.14).

Crossdating of the oak samples between them allowed identification of elements of the barrels that were obtained from the same tree (for details, see Domínguez-Delmás and García-González 2015d):

- Barrel 1: staves B1.1 and B1.13 (their series have been averaged into the curve DLT5-17T, with 58 rings), staves B1.3, B1.10, and B1.16 (DLT7-14-20T, 63 rings);
- Barrel 2, staves B2.1 and B2.3 (DLT21-23T, 51 rings), staves B2.4 and B2.8 (DLT24-28T, 67 rings);
- Barrel 4, cover 1, tables A and B (DLT29-30T, 161 rings);
- Barrel 2, stave 7 and Barrel 5, stave 1 (DLT27-33T, 81 rings)

In addition to these synchronizations between barrel elements obtained from the same individual trees, correlations have been found between some series that indicate that the wood originated from the same forest (e.g., DLT21-23T, DLT24-28T and DLT00221; and DLT5-17T with 27-33T, which either originate from the same tree or the same forest).

Crossdating of the mean curves and the rest of the individual oak series with reference chronologies of oak from Northern, Central, and Eastern Europe (England, France, the Netherlands, Germany, Poland, Denmark, Norway, and Sweden) provided absolute dates for some barrel staves and the head of a barrel with chronologies from the southeastern Baltic (Table 1.15). The rest of the samples remain undated.

Table 1.13 Results of the species identification and dendrochronological research

Sample code	Timber element	Dendro code	Species	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
M116	Frame	DLT00010	2	71	1	53	LW	0.92	0.43
M119	Frame	DLT00020	1	54	–	13	–	1.07	0.52
M126	Frame	DLT00030	1	206	–	14	–	0.72	0.29
M127	–	DLT00041	1	66	–	0	–	0.65	0.22
B1.1	Barrel 1, stave 1	DLT00051	1	58	–	0	–	1.14	0.44
B1.2	Barrel 1, stave 2	DLT00061	1	29	–	0	–	1.63	0.40
B1.3	Barrel 1, stave 3	DLT00071	1	39	–	0	–	1.60	0.50
B1.4	Barrel 1, stave 4	DLT00081	1	72	–	0	–	0.89	0.18
B1.5	Barrel 1, stave 5	DLT00091	1	47	–	0	–	0.66	0.21
B1.6	Barrel 1, stave 6	DLT00101	1	32	–	0	–	1.60	0.41
B1.7	Barrel 1, stave 7	DLT00111	1	36	–	0	–	1.23	0.19
B1.8	Barrel 1, stave 8	DLT00121	1	46	–	0	–	1.15	0.32
B1.9	Barrel 1, stave 9	DLT00131	1	57	–	0	–	1.19	0.22
B1.10	Barrel 1, stave 10	DLT00141	1	37	–	0	–	1.67	0.53
B1.11	Barrel 1, stave 11	DLT00151	1	24	–	0	–	1.88	0.34
B1.12	Barrel 1, stave 12	DLT00161	1	36	–	0	–	1.64	0.47
B1.13	Barrel 1, stave 13	DLT00171	1	33	–	0	–	1.70	0.58
B1.14	Barrel 1, stave 14	DLT00181	1	31	–	0	–	1.79	0.43
B1.15	Barrel 1, stave 15	DLT00191	1	57	–	0	–	1.09	0.25
B1.16	Barrel 1, stave 16	DLT00201	1	45	–	0	–	1.40	0.36
B2.1	Barrel 2, stave 1	DLT00211	1	40	–	0	–	1.36	0.54
B2.2	Barrel 2, stave 2	DLT00221	1	47	–	0	–	1.22	0.27
B2.3	Barrel 2, stave 3	DLT00231	1	50	–	0	–	1.04	0.31
B2.4	Barrel 2, stave 4	DLT00241	1	42	–	3	–	1.48	0.23
B2.5	Barrel 2, stave 5	DLT00251	1	59	–	0	–	0.87	0.40

(continued)

Table 1.13 (continued)

Sample code	Timber element	Dendro code	Species	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
B2.6	Barrel 2, stave 6	DLT00261	1	34	–	0	–	1.55	0.30
B2.7	**Barrel 2, stave 7**	**DLT00271**	1	81	–	0	–	1.09	0.39
B2.8	Barrel 2, stave 8	DLT00281	1	66	–	2	–	1.40	0.29
B4. T1A	**Barrel 4, lid 1, tabla A**	**DLT00291**	1	146	–	1	–	0.93	0.39
B4. T1B	Barrel 4, lid 1, tabla B	DLT00301	1	161	–	–	–	0.99	0.36
B4. T2B	Barrel 4, lid 2, tabla B	DLT00311	1	107	–	–	–	1.27	0.34
B4. T2C	Barrel 4, lid 2, tabla C	DLT00321	1	82	–	–	–	1.68	0.33
B5.1	**Barrel 5, stave 1**	**DLT00331**	1	61	–	–	–	1.11	0.36
M51	Hoop	–	4	ca. 22	+	n.a.	+, LW	–	
M92	Stave	–	1	30	–	0	–	Insufficient number of rings for dendrochronological analysis	
M117	–	–	2	ca. 18		0	–	–	
M120	Keelson	–	2	4	–	0	–	–	
M129	–	–	1	11	+	0	–	Insufficient number of rings for dendrochronological analysis	
M136	–	–	1	35	–	0	–	Inspected at CAS but was not transported to the laboratory at USC	
M139	–	–	3	28	–	n.a.	+, LW	Insufficient number of rings for dendrochronological analysis	
M140	Bulkhead	–	3	24	ca. 5	n.a.	–	Insufficient number of rings for dendrochronological analysis	

Species: 1, *Quercus* subg. *Quercus*; 2, unidentified conifer; 3, *Fagus sylvatica*; 4, *Rhamnus* sp.; N: number of rings; Pith: present (1)/absent (–); SR: sapwood rings; n.a.: not applicable; Bark edge: present (LW, latewood)/absent (–); MRW: mean ring width; σ: standard deviation of MRW. Barrel elements from which a wood sample was sectioned for dendrochronological analysis have been marked in bold. The rest of the elements of the barrels were analyzed using digital photographs

Table 1.14 Samples taken for observation of anatomical characteristics and species identification

Sample code	Timber element	Species/observations
M132	–	No identification
M133	–	No identification
M141	–	No identification
M915	–	No identification
Box 2	lid	Tropical, unidentified
Box 6, M936	Front piece	Tropical, unidentified
Box 6	Lateral A	Tropical, unidentified
Box 6	Lateral B	Tropical, unidentified

4.12 Arade 1

While the timbers are housed at the *Divisão de Arqueologia Náutica e Subaquática, Instituto de Gestão do PatrimónioArquitectónico e Arqueológico* (DANS/IGESPAR) in Lisbon, the wreck was originally discovered by recreational divers in 1970, then rediscovered in 2001 and excavated and recorded in several years by divers of the former *Centro Nacional de Arqueologia Náutica e Subaquática* (CNANS) and students from Texas A&M University.

The Arade 1 was a skeleton-first, carvel-built vessel, and radiocarbon dates placed its construction between the fifteenth and seventeenth centuries (Castro 2006). Preliminary dendrochronological dating (conducted by Tomasz Wazny in 2005) on five timbers produced a felling date for one of the parent trees between 1577 and 1589, which provided a *terminus post quem* for the ship's construction, thus tightening the range yielded by the previously conducted ^{14}C analyses.

Also in 2005, 18 samples of wood from the wreck were analyzed by the *Centro de Investigacão em Paleoecologia Humana* (CIPH) of the former *Instituto Português de Arqueologia* in Lisbon, and were identified as Portuguese oak (*Q. faginea*) and cork oak (*Q. suber*). These identifications led to the hypothesis that the ship had been constructed locally with materials from the Iberian Peninsula; however, the basis for this hypothesis was called into question when the identification key used by researchers of the CIPH was not made available to us to reproduce those identifications. Since the discrimination of deciduous oaks such as *Q. faginea* is not possible based on wood anatomical features alone, we decided to revisit those identifications.

With the aim of dating the ship's construction and find out what species was used in its construction, we carefully selected and collected new samples from 42 timbers, including 6 of the timbers previously sampled for wood identification (the ones identified as *Q. faginea* and *Q. suber*). New identifications were performed on all 42 samples in accordance with Schweingruber (1990). Of the total timbers represented, 40 were identified as deciduous oak, including one of the timbers previously identified as cork oak (which is an evergreen species) and two others were identified as chestnut (*Castanea sativa*) (Domínguez-Delmás et al. 2013). These

Table 1.15 Results of the dendrochronological dating of Delta II

Sample code	Dendro code	N	SR	Bark edge[a]	First year	Final year	Felling date	TBP	CC	Gl	Chronology
B1.1, B1.13	DLT5-17T	58	0	>8	1512	1569	After 1577	5.67	0.60	69**	sch1115m[b]
B4.T1A, B4.T1B	DLT29-30T	161	1	8–23	1418	1578	Between 1586 and 1601	5.85	0.41	65.8***	NLARTPOL[c]
B2.7, B5.1	DLT27-33T	81	0	>8	1498	1578	After 1586	6.73	0.59	69.8***	sch1115m
B1.1-B1.13 B2.7-B5.1	DLT5-17_27-33M	81	n.a.	n.a.	1498	1578	n.a.	7.63	0.64	74.7***	sch1115m

N: number of rings; SR: sapwood rings; TBP: Student's *t*-value adapted according to Baillie and Pilcher (1973); CC: correlation coefficient; Gl: percentage of parallel variation as defined by Eckstein and Bauch (1969); asterisks represent the signification level of Gl (**, $p < 0.01$; ***, $p < 0.001$)
[a]Estimation of sapwood rings missing till the bark edge based on Wazny (1990) for a 90% confidence interval
[b]Bauch et al. (1972), Eckstein et al. (1975)
[c]Jansma et al. (2004)

species grow and coexist over vast areas of European continent, so the hypothetical construction site of Iberia had to be withdrawn.

The dendrochronological research included 4 tree-ring series obtained by Wazny and 24 series obtained from the newly collected samples. Internal cross-matching demonstrated that six of the planks originated from the same three trees. Most of the planking elements had high statistical correlations internally, as did most of the framing elements, which demonstrates a homogenous group of parent trees, lending itself to successful dating and provenance of the wreck assemblage.

Crossdating against master and local chronologies produced precise felling dates for frame samples that retained bark edge between the spring/summer of 1579 and the spring/summer/winter of 1582/1583 (Domínguez-Delmás et al. 2013). These dates, combined with the *terminus post quem* of the dated samples without sapwood, led to the conclusion that all the trees used in the ship's construction were felled from the late 1570s to 1583, suggesting soon after 1583 as the likely time of construction. Furthermore, the oak series (and separately, the chestnut samples) produced a strong statistical correlation with the oak reference chronology for the area of Western France along the Loire River in Fontevraud, where the timber—oak and chestnut—for this ship was likely sourced. Where it was constructed, however, remains unknown, although a shipyard in France or the Iberian Peninsula remains likely.

4.13 Punta Restelos

The Punta Restelos shipwreck was located in 2007 by Archeonauta S.L. at Punta Restelos, near the Finisterre Cape in the northwestern coast of Galicia (Spain) (San Claudio Santa Cruz 2008, 2009). Preliminarily, it was identified as the wreckage of the galleon *Santa María la Anunciada*, a ship that was built in Vietri sul Mare, Salerno, around 1590, and that sunk in 1596 while taking part on the fleet commanded by Martin de Padilla during the Anglo-Spanish War (San Claudio Santa Cruz 2012, 2015).

During an archaeological campaign in 2012, seven pieces of timber fragments were recovered from the wreck site with the aim to date and provenance the wood, although none of these timbers was removed from the ship's structure itself, so their relationship to the site is questionable.

All the samples were identified as deciduous oak (*Quercus* subg. *Quercus*). Only two samples had 90 rings or more. The rest had less than 50 rings (Table 1.16). However, one of those samples with only 41 rings presented a very sensitive growth pattern, so it was included in the dendrochronological analysis to assess its synchronization with the longer, suitable, samples.

The internal crossdating revealed a match between the tree-ring series from samples 1 and 7, while no match was found between samples 1 and 3.

Crossdating with reference chronologies resulted in the dating of the three samples with chronologies from northeastern Poland (Domínguez-Delmás 2014).

Table 1.16 Results of the wood identification and suitability of the samples for dendrochronological research for the Punta Restelos wreck

Sample code	Timber element	Dendro code	Species	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
1	Unknown	S0010020	1	90	–	4	–	1.52	0.60
2	Unknown	Invalid	1	12	–	0	–	–	–
3	Unknown	S0010010	1	116(+8)	–	6(+8)	–	0.79	0.28
4	Unknown	Invalid	1	29	+1	0	–	–	–
5	Unknown	Invalid	1	10	–	0	–	–	–
6	Unknown	Invalid	1	31	+1	0	–	–	–
7	Unknown	S0010030	1	41	–	0	–	0.74	0.16

Adapted from Domínguez-Delmás (2014); Pith: present (+1)/absent (−); SR: sapwood rings; Bark edge: present (+)/absent (−); MRW: mean ring width; σ: standard deviation

The most recent ring measured in sample 3 dates to 1566, and accounting for the presence of six measured sapwood rings and another eight that could be seen but not measured, an interval for the felling of the tree was estimated between 1574 and 1584. Sample 1 contained four sapwood rings and the outermost one dated to 1438. Given the provenance of the wood in northeast Poland, the estimated felling date of this tree was established between 1443 and 1458. The relative match between samples 7 and 1 allowed anchoring the former in time, with an absolute date for the outermost ring of 1414. This tree was cut sometime after 1422, but the lack of sapwood hampers the possibility to estimate the felling date within a range of years.

Although most of the recovered elements contain an insufficient number of tree rings to be considered suitable for dendrochronological research, the three selected samples could be dated, and their provenance was established in northeastern Poland. The estimated felling date for the parent tree of sample 3 (1574–1584) would allow placing this timber in the context of a ship from Padilla's 1596 fleet. However, the fact that this timber was found out of context (i.e., not directly linked to the ship's structure) calls for caution when inferring conclusions regarding the date or identity of the ship. The same applies to the other two dated samples. Given that they were not found in connection with the ship's structure, it is not possible to infer further information from their date and provenance. Furthermore, the estimated interval for the felling of the parent tree of sample 1 (1443–1458) would exclude this timber as an original element from a ship built in the second half of the sixteenth century. The likelihood that this could be a reused timber in a ship from this period seems very slim. Given that this element was found out of context, it seems more likely that it belongs to another shipwreck. The lack of sapwood in sample 7 impedes the placement of this element within a temporal context other than after 1422, which is a *terminus post quem*.

The Polish provenance of the wood does not exclude the possibility that the ship(s) was (were) built in the Iberian Peninsula. Import of different species of Baltic wood to markets in Western Europe has been broadly reported (e.g., Albion 1926; De Vries and Van der Woude 1997 and references therein; Brand 2007). More specifically, Bogucka (1969) describes the export of products (including wood) from Poland to the Iberian Peninsula, and Casado Soto (1998) reports that a 1522 inventory of ships from Cantabrian harbors included ships built with local oak and oak from Northern Europe. Other scholars also refer to the import of wood from Northern Europe to Iberia for shipbuilding (Bauer 1980; Aranda y Antón 1990; García Fernández 2005), but often these references are very generic and unspecific, or cover later periods (seventeenth to eighteenth centuries). Therefore, the recovered material could very well belong to a ship or ships built in Iberia with imported wood.

In spite of the limitations presented by the analyzed material, the results are very promising. Future campaigns should be directed at locating the remains of the ship's hull and sampling structural timbers from it, so that future dendrochronological results can be placed in a more specific context and so that more specific conclusions can be drawn.

4.14 Ribadeo

In 2011, the wreckage of a galleon was found during dredging works in the river near the town of Ribadeo (NW Spain). Archaeological investigations carried out in 2012 estimated a sixteenth-century date based on associated artifacts and construction features (San Claudio Santa Cruz et al. 2013). Two chapters in this volume describe the site in more detail—in Chapter 3, Vol. 2, Miguel San Claudio, the lead archaeologist provides an overview, while in Chapter 4, Vol. 2, the ForSEAdiscovery multidisciplinary team which worked on the site reprise the paper presented at the IKUWA6 conference in Fremantle, Australia in 2016 and published in the conference proceedings (Eguiluz Miranda et al. 2020). These Chapters 3 and 4, therefore, contain a detailed account of the dendrochronological analysis of the Ribadeo wreck timber samples.

4.15 Delta I

The Delta I wreck was detected during work in the port area of the Bay of Cádiz (see also Chapter 6, Vol. 2). The construction characteristics point to the ship of Iberian–Atlantic construction, and the silver bars from the cargo date it around the mid-seventeenth century (Higueras-Milena and Gallardo 2016).

In an attempt to date the shipwreck, fragments of wood of different sizes were sawn underwater from several structural elements by archaeologists from TANIT. A preliminary inspection was carried out at the facilities of the Underwater Archaeology Centre of Cádiz (CAS), to be researched subsequently at the dendro lab of the University of Santiago de Compostela.

All the samples except four corresponded to the subgenus of deciduous oaks (*Quercus* subg. *Quercus*) (Table 1.17, adapted from Domínguez-Delmás and

Table 1.17 Results of the species identification and dendrochronological research

Sample code	Timber element	Dendro code	Species	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
M13	?	Invalid	2	9	–	0	–	–	–
M16	?	Invalid	3	35	–	0	–	–	–
M20a	Peg	S0030051	1	43	–	0	–	0.63	0.14
M20b	Peg	S0030061	1	36	–	0	–	0.70	0.21
M20c	Peg	S0030071	1	28	–	0	–	0.78	0.19
M20d	Peg	S0030081	1	23	–	0	–	1.11	0.49
M21	?	Invalid	1	10	–	0	–	–	–
M25	?	Invalid	1	10	1	0	–	–	–
M26	Peg	Invalid	1	21	–	0	–	–	–
M27	?	Invalid	1	11	–	1	–	–	–
M28	?	Invalid	1	28	ca.10	0	–	–	–
M29	?	Invalid	1	7	–	0	–	–	–
M30	?	Invalid	1	18	–	0	–	–	–
M31	?	Invalid	1	20	–	0	–	–	–
M32	?	Invalid	1	21	–	12	1+/−1	–	–
M33	?	S0030090	2	88	–	0	–	1.02	0.38
M34	Plank	Invalid	1	38	1	0	–	–	–
M35	Plank	S0030020	1	139	–	0	–	1.00	0.22
M36	Peg	Invalid	1	15	–	0	–	–	–
M37	?	S0030100	2	83	–	0	–	1.27	0.40
M38	?	Invalid	1	23	–	0	–	–	–
M39	?	S0030040	1	81	–	0	–	1.26	0.56
M40	?	Invalid	1	4	–	0	–	–	–
M41	?	Invalid	1	7	–	0	–	–	–
M42	Floor timber	S0030030	1	122	ca. 20	0	–	1.29	0.53
D770	Keel	S0030010	1	90	–	0	–	2.56	1.81

Adapted from Domínguez-Delmás and García-González (2015)
Species: 1, *Quercus* subg. *Quercus*; 2, *Pinus sylvestris/nigra*; 3, *Fagus sylvatica*; N: number of rings; Pith: present (1)/absent (−); SR: sapwood rings; Bark edge: present (+)/absent (−); MRW: mean ring width; σ: standard deviation. Pith: present (+1)/absent (−); Bark edge: present (+)/absent (−)

García-González 2015g). Three elements (M13, M33, and M37) were identified as pine (*Pinus* sp.) of the type *P. sylvestris/nigra*, and one sample (M16) as beech (*Fagus sylvatica*).

Four samples of oak (M35, M39, M42, and D770) and two of pine (M33 and M37) contained more than 80 rings, so they were selected for dendrochronological research. The treenails that made up the M20 sample were also analyzed to test whether their tree-ring series synchronized with each other. The rest of the fragments had been collected for wood identification and contained less than 40 rings, hence were not suitable for dendrochronological investigation. However, considering that many of them were only fragments and showed slow growth, it is justifiable to assume that a complete cross-section of those timbers would provide sufficient rings for the research. Those observations were therefore noted in case a future campaign on this shipwreck is ever carried out (see Domínguez-Delmás and García-González 2015g for details) (Table 1.17).

Crossdating attempts between the samples did not produce matching results. It was also not possible to synchronize the series obtained from the treenails of the M20 sample. The comparison with reference chronologies of oak and pine from Northern, Central, and Eastern Europe (England, France, the Netherlands, Germany, Poland, Denmark, Norway, and Sweden) did not provide conclusive results.

Should another sampling campaign be planned on this shipwreck, it is strongly recommended to take samples (complete cross-sections) of the elements whose fragments showed slow growth (M28, M30, M31), as well as the elements whose fragments showed fast growth, but could have dendrochronological potential if the specimen is large (timbers M25, M27, and M32). Likewise, given the number of rings present in the oak samples M35, M39, and M42, and in the pine M33 and M37 samples, it is recommended to carry out a new intervention on the wreck in order to sample more construction elements of the same type, as that would increase the chances to find cross-matches between the samples to develop an object chronology, which are usually easier to date than series derived from single timbers.

4.16 Delta III

Like Delta I and II, the Delta III wreck was detected during works to expand the harbor in the bay of Cadiz. To find the primary construction date of the ship and identify the species used in different structural elements, 12 wood samples were taken from several structural elements and barrel staves in June 2016 by Nigel Nayling during diving operations.

Seven samples were oak (*Quercus* subg. *Quercus*), three were pine (*Pinus sylvestris/nigra*), and two others were beech (*Fagus sylvatica*) (Table 1.18).

Crossdating of the oak samples between them allowed identifying correlations between the samples 6, 7, 8, and 9 (see Domínguez-Delmás and Nayling 2016 for details). These series have been averaged into the object chronology DEL4MMMM (191 rings). Comparison of this mean curve and all the individual oak series with the reference chronologies has resulted in the absolute dating of DEL4MMMM (Table 1.19). The presence of sapwood in sample 7 made it possible to estimate the cutting date of the tree between 1663 and 1675. For the other three samples, only *terminus post quem* dates (dates after which the trees were felled) could be estimated. In all three cases, these dates are earlier than the estimated cutting interval for the Dendro 7 sample.

The reference chronology providing the best correlation with the dated series (NLGERM05, Domínguez-Delmás, unpublished) which is made up of series from

Table 1.18 Results of the species identification and dendrochronological inspection

Sample code	Timber element	Dendro code	Species	N	Pith	SR	MRW (mm)	σ (mm)
Dendro 1	Frame	DEL00011	1	62	–	–	1.53	0.83
Dendro 2	Sacrificial planking	–	2	–	–	–	–	–
Dendro 3	Sacrificial planking	DEL00021	2	60	–	?	2.04	0.68
Dendro 4	Sacrificial planking	–	2	–	–	–	–	–
Dendro 5	Hull plank	DEL00030	1	65	–	–	1.99	0.35
Dendro 6	Hull plank	DEL00040	1	106	–	–	1.72	0.40
Dendro 7	Ceiling plank	DEL00051	1	153	Ca.5	2	1.37	0.53
Dendro 8	Ceiling plank	DEL00060	1	115	–	–	1.55	0.36
Dendro 9	Ceiling plank	DEL00071	1	91	–	–	2.20	0.86
Dendro 10	Ceiling plank	–	1	35	–	–	–	–
Dendro 11	Keel	–	3	20		n.a.	–	–
Dendro 12A	Stave	DEL00081	3	25	–	n.a.	2.93	1.19
Dendro 12B	Stave	DEL00091	3	64	–	n.a.	1.15	0.58

Adapted from Domínguez-Delmás and Nayling (2016)

Species: 1, *Quercus* subg. *Quercus*; 2, *Pinus* sp. type *sylvestris/nigra*; 3, *Fagus sylvatica*; N: number of rings; Pith: present (1)/absent (−); SR: sapwood rings; n.a.: not applicable; Bark edge: present (+)/absent (−); MRW: mean ring width; σ: standard deviation

wood found in archaeological sites in the Netherlands, but that was imported from West Germany. Therefore, it is likely that the dated timbers from the Delta III originate from the same or neighboring geographic areas.

The oak sample Dendro 1 shows distortion in the growth pattern that, together with the low number of rings ($N = 62$), may have contributed to impede the dating of this element. The pine samples (Dendro 2, 3, and 4) also remain undated, as do the beech samples from the barrel staves (Dendro 12A and 12B).

Although the end year of sample Dendro 6 dates from the second half of the sixteenth century, it is possible that many rings are missing in the outermost part of the sample. Therefore, it cannot be ruled out that this wood is contemporary with the other three dated samples. If all the dated samples belong to the original construction of the ship, it is probable that the felling of the trees took place between 1663 and 1675, as has been estimated for sample Dendro 7.

The dendrochronological results have also allowed us to infer the area of origin of the dated wood, which is native to West Germany. In the seventeenth century, this area supplied timber to the low countries (e.g., De Vries and Van der Woude 1997), which is consistent with the initial assessment of the ship being a Dutch merchantman.

Table 1.19 Results of the dendrochronological dating for the Delta III wreck

Sample code	Dendro code	N	SR	Bark edge[a]	First year	Final year	Felling date	TBP	CC	Gl	Chronology
Dendro 6	DEL00040	106	–	>13	1461	1566	After 1579	6.61	0.562	70.8***	NLGERM05
Dendro 7	DEL00051	153	2	[12–24]	1499	1651	Between 1663 and 1675	6.75	0.465	71.9***	NLGERM05
Dendro 8	DEL00060	115	–	>13	1528	1642	After 1655	5.12	0.422	69.6***	NLGERM05
Dendro 9	DEL00071	91	–	>13	1531	1621	After 1634	5.01	0.462	72***	NLGERM05
Dendro 6 Dendro 7 Dendro 8 Dendro 9	DEL4MMMM	191	–	–	1461	1651	–	8.88	0.532	77.7***	NLGERM05

[a]Estimation of sapwood rings missing till the bark edge based on Hollstein (1980) for oaks 100–200 years old

N: number of rings; SR: sapwood rings; TBP: Student's *t*-value adapted according to Baillie and Pilcher (1973); CC: correlation coefficient; Gl: percentage of parallel variation as defined by Eckstein and Bauch (1969), asterisks represent the signification level of GL (***, $p < 0.001$)

4.17 Matagrana

In 2008, Atlantic storms caused sand dunes to recede at Portil Beach in Huelva (Spain), revealing a shipwreck of 16.81 m long and 5.48 m wide (Fig. 1.4c). The wreck assemblage was excavated, documented, and reburied again by a team of the *Centro de Arqueología Subacuática* (CAS) of Cadiz, and has been interpreted as an English merchant vessel dating from the late seventeenth to the mid-eighteenth century (Rodríguez Mariscal 2016).

A sample from a framing element (MATA/HU-08/M1) was examined for wood identification and was determined to be *Quercus ilex* (Menguiano Chaparro 2008), an evergreen oak species native to the Iberian Peninsula. Another sample from a different framing element (frame 21) was collected by manual sawing and subjected to tree-ring analysis (Table 1.20; Domínguez-Delmás 2010b). The species corresponded to the group of deciduous oaks (*Quercus* subg. *Quercus*) and a series with 88 rings was obtained. The sample contained the pith but lacked sapwood, and it remains undated.

Based on those initial identifications, the archaeologists could establish that most of the framing elements were made of deciduous oak, whereas only a few were made of oak holm (*Q. ilex*).

4.18 Triunfante

Triunfante was the first ship from the Spanish navy ever being excavated by nautical archaeologists in Spain. This 68-gun ship of the line was built in Ferrol shipyard (NW Spain) between 1754 and 1756, and after almost four decades of service, it sunk in 1795 in the Mediterranean off the Cabo de Rosas (NE Spain) (Fuente de Pablo 2006, p. 138).

In 2009, a section of the shipwreck was excavated by the Centre d'Arqueología Subacuàtica de Catalunya (CASC) and Marta Domínguez-Delmás was invited to inspect the shipwreck and collect samples. The excellent visibility of the shallow (7–8 m depth) Mediterranean waters where *Triunfante* is resting allowed identifying the framing elements as deciduous oak, whereas the hull planks were made of a conifer species (Fig. 1.4d). Ring counts were carried out underwater on the end grain of the framing elements. With approximate dimensions of 40 × 40 cm and 38–45 rings, it was immediately understood that the oak frames were derived from

Table 1.20 Results of dendrochronological research of the Matagrana shipwreck

Sample nr	Timber element	Dendro code	Species	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
21	Frame	SMG00010	1	88	1	0	–	1.12	0.33

Species: 1, *Quercus* subg. *Quercus*; Pith: present (1)/absent (−); SR: sapwood rings; Bark edge: present (+)/absent (−); MRW: mean ring width; σ: standard deviation MRW young, fast-grown trees, which according to historical documents originate from the north of Spain, possibly from the Basque Country (Fuente de Pablo 2006, pp. 104–106). Samples were collected from six hull planks, and from three additional planks (two of conifer and one of oak) which were on the wreck but out of context.

Once at the laboratory of the Ring Foundation in the Netherlands, all the conifer samples collected were identified as pine (*P. sylvestris/nigra*) (Table 1.21). Crossdating between the samples revealed excellent matches between five of the pine samples (dendro codes SST010, 20, 30, 40, and 60; Domínguez-Delmás, 2010c), indicating that these pines originate from the same area. These series have been averaged into an object chronology (SST5MM). Sample SST050 shows a weaker match and has been left out of the mean curve. SST070 shows no correlation with the mean curve or with sample SST050. Similarly, no correlation was found between the oak samples indicating that either they do not cover the same period (or overlap just a few years) or that they originate from different areas. However, given that those oak samples and the pine sample SST070 were out of context, no information can be extrapolated from them.

Triunfante sailed for almost 40 years, and it is known that it underwent repairs in several occasions, probably at Cartagena shipyard, which is where the ship had its base (Pujol i Hamelink et al. 2013). The presence of iron nails in the hull planking indicates that the outer hull was repaired after 1764, therefore the researched hull planks do not belong to the original construction (Pujol i Hamelink et al. 2013, pp. 146–147 and 179). Unfortunately, crossdating with reference chronologies did not result in a date, hence we cannot attest when the pines for the hull planks were potentially cut.

Table 1.21 Results of the species identification and dendrochronological inspection of samples from *Triunfante* (Domínguez-Delmás 2010c)

Sample code	Timber element	Species	Dendro code	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
T1E	Hull plank	2	SST010	117	1	–	–	1.46	0.70
T13E	Hull plank	2	SST020	222	C.10	–	–	0.79	0.56
T2?E	Hull plank	2	SST030	56	1	–	–	2.62	1.25
T2?E	Hull plank	2	SST040	184	C.10	46	–	0.91	0.60
T3E	Hull plank	2	SST050	140	1	–	–	1.25	0.60
T14E	Hull plank	2	SST060	155	C.5	15	–	1.07	0.87
–	Plank out of context	2	SST070	103	–	–	–	0.95	0.33
–	Plank out of context	1	SST080	93	–	s.b.	–	0.90	0.30
–	Plank out of context (found under T14E but without number)	1	SST090	94	C.5	26 + 1	–	1.89	1.02

Species: 1, *Quercus* subg. *Quercus*; 2, *Pinus* sp. type *sylvestris/nigra*; 3, *Fagus sylvatica*; *N*: number of rings; Pith: present (1)/absent (−); SR: sapwood rings; n.a.: not applicable; Bark edge: present (+)/absent (−); MRW: mean ring width; σ: standard deviation

4.19 Magdalena

The *Santa Maria Magdalena* ship was a frigate of the Spanish Royal Navy built in Ferrol (province of Galicia) in 1778 which sank off Covas in Viveiro (province of Lugo) on November 2, 1810. Chapter 9, Vol. 2 in this volume describes the site in more detail where the ForSEAdiscovery multidisciplinary team which worked on the site reprises the paper presented at the IKUWA6 conference in Fremantle, Australia in 2016 and published in the conference proceedings (Trindade et al. 2020). The chapter contains a detailed account of the dendrochronological analysis of the *Magdalena* wreck timber samples.

4.20 San Sebastián

This shipwreck, known as "*pecio de los bajos de San Sebastián,*" corresponds to a mid-size military vessel dating to the late eighteenth or early nineteenth century based on associated archaeological material (see Chapter 6, Vol. 2 and Martí Solano 2013). A sample was obtained from one radial hull plank, which delivered a series with 77 rings (Table 1.22; Domínguez-Delmás 2010d). Pith and sapwood were absent on the sample, and it remains undated.

4.21 Bayonnaise

Bayonnaise was a corvette from the French Royal Navy. Built in Bayonne (France) in 1794, she wrecked in 1803 at Playa Langosteiras, Finisterre (province of Coruña, Spain). The shipwreck was located in 2010 by Archaeonauta S.L. during an inventory of underwater archaeological heritage along Galician coasts. The underwater archaeology team of the ForSEAdiscovery project carried out a campaign in June 2015 and collected samples from ten timber elements for dendrochronological research.

The preliminary inspection served to identify all the samples as deciduous oak (*Quercus* subg. *Quercus*). Only four samples (A-BAY01-007W-01S, -008W-01S, -009W-01S, and -010W-01S) were selected for tree-ring analysis, and from those, only two had 60 rings or more (Table 1.23) (Domínguez-Delmás and

Table 1.22 Results of dendrochronological research of the San Sebastian shipwreck

Sample code	Timber element	Dendro code	Species	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
–	Hull plank	SSE0001071	1	77	–	0	–	1.438	1.061

Adapted after Domínguez-Delmás (2010d). Species: 1, *Quercus* subg. *Quercus*; N: number of rings; Pith: present (1)/absent (−); SR: sapwood rings; Bark edge: present (+)/absent (−); MRW: mean ring width; σ: standard deviation

Table 1.23 Results of dendrochronological research of the Bayonnaise shipwreck

Sample code	Timber element	Dendro code	Species	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
A-BAY01-007W-01S A-BAY01-007W-02S	Frame	BAY00010	1	60	+	5	–	2.92	1.23
A-BAY01–008W-01S	Frame	BAY00021	1	67	–	0	–	2.33	1.01
A-BAY01-009W-01S	Frame	BAY00031	1	36	–	0	–	2.31	1.26
A-BAY01-010W-01S	Frame	BAY00041	1	36	–	0	–	2.64	1.12
A-BAY01-001W-01S A-BAY01-001W-02S	Frame Frame	– –	1	27 28	– –	– –	– –	Not measured due to low number of tree rings	
A-BAY01-002W-01S A-BAY01-002W-02S	Plank Tree nail	– –	1	20 17	+ –	– –	– –	Not measured due to low number of tree rings	
A-BAY01-003W-01S	Frame	–	1	ca.15?	+	–	–	Unsuitable sample for dendrochronological research due to severe damage by *T. navalis*	
A-BAY01-004W-01S	Frame	–	1	Unknown	?	–	–	Unsuitable sample for dendrochronological research due to severe damage by *T. navalis*	
A-BAY01-005W-01S	Frame	–	1	ca.20?	–	–	–	Unsuitable sample for dendrochronological research due to severe damage by *T. navalis*	
A-BAY01–006W-01S	?	–	1	8 20 12	– – –	8 0 0	– – – –	Unsuitable sample for dendrochronological research due to severe damage by *T. navalis*	

Species: 1, *Quercus* subg. *Quercus*; *N*: number of rings; Pith: present (1)/absent (−); SR: sapwood rings; Bark edge: present (+)/absent (−); MRW: mean ring width; σ: standard deviation MRW

García-González 2015c). The rest of the samples were either too damaged by *Teredo navalis* or too fragmented to contain more than 30 rings in a continuous series.

Most of the samples presented severe damage caused by *Teredo navalis*, which resulted in the fragmentation of the samples into pieces where no tree-ring series could be retrieved. Furthermore, the samples where continuous tree-ring series could be measured contained between 36 and 67 tree rings. Such short series are far from the optimum of what can be considered suitable for dendrochronological research, so not surprisingly, the crossdating of tree-ring series from this site, as well as with European oak reference chronologies, did not produce statistically sound results. Therefore, all samples remain for now undated.

4.22 *Cee 1*

The location of the *Cee 1* shipwreck at Corcubion Bay (province of A Coruña, Spain) was communicated to San Claudio Santa Cruz (Archaeonauta S.L.) by sport divers in the village of Cée (San Claudio Santa Cruz, pers. comm.). In a photograph of Corcubion Bay from the late nineteenth to early twentieth century, a wrecked ship can be observed still floating at the approximate point where the shipwreck lies today. Therefore, this is probably a late-nineteenth-century ship, which has tentatively been identified as the Spanish brig *Francisca Rosa*, abandoned at this site in 1904. In June 2015, ForSEAdiscovery's nautical archaeology team carried out a campaign on the site to collect wood samples for dendrochronological research.

Five of the samples were identified as deciduous oak (*Quercus* subg. *Quercus*) and one as a conifer, although the species of this conifer sample could not be determined (Table 1.24) (Domínguez-Delmás, M. García-González 2015a). One oak sample was discarded for further research, as it contained insufficient rings.

The comparison of the tree-ring series between them, as well as with European oak reference chronologies, did not produce statistically sound results. Therefore, all samples remain for now undated.

4.23 *Cee 2*

The *Cee 2* shipwreck was located in June 2015 at Corcubion Bay (province of Coruña, Spain) by the underwater archaeology team of the ForSEAdiscovery project, while carrying out the search for the *Cee 1* shipwreck. The wreck site was inspected, and three samples were collected for dendrochronological research.

The samples were identified as deciduous oak (*Quercus* subg. *Quercus*). The presence of pith and sapwood was registered, but the ring count revealed that the samples had insufficient rings for dendrochronological research (Table 1.25) (Domínguez-Delmás, M. García-González 2015b).

Table 1.24 Results of species identification and dendrochronological research

Sample nr	Timber element	Dendro code	Species	N	Pith	SR	Bark edge	MRW (mm)	σ (mm)
CEE01-002W-01S	Slice taken from hull plank	CEE00011	2	41	+	0	–	3.20	1.35
CEE01-003W-01S	Sawn from in situ copper pin	CEE00021	1	130	–	10	–	0.97	0.32
CEE01-004W-01S	Stray copper pin with surrounding wood; framing element?	CEE00030	1	50	ca.5	0	–	2.15	0.63
CEE01–006W-01S	Stray eroded fragment	CEE00041	1	68	+	–	–	1.31	0.85
CEE01-007W-01S	Stray long copper pin	CEE00050	1	62	+	9	–	2.34	0.77
CEE01-005W-01S	Wood sample from upper end of in situ copper pin	–	1	14	–	0	–	Not suitable for dendro research	

Species: 1, *Quercus* subg. *Quercus*; 2, conifer (unidentified); *N*: number of rings; Pith: present (1)/absent (−); SR: sapwood rings; Bark edge: present (+)/absent (−); MRW: mean ring width; *σ*: standard deviation MRW

Table 1.25 Results of species identification and dendrochronological research

Sample nr	Timber element	Species	N	Pith	SR	Bark Edge
A-CEE02-001W-01S	Frame	1	40	+	0	–
A-CEE02-002W-01S	Plank	1	24	–	6	–
A-CEE02-003W-01S	Frame	1	34	+	–	–

Species: 1, *Quercus* subg. *Quercus*; *N*: number of rings; Pith: present (1)/absent (−); SR: sapwood rings; Bark edge: present (+)/absent (−)

5 Discussion

Over these years and through the study of each new shipwreck, whether built in the Iberian Peninsula or elsewhere, our knowledge has increased, not only about matters related to wood supply and shipbuilding but also about how to approach the research of shipwreck assemblages. In this discussion, we first want to highlight some observations and patterns that emerge when compiling the data of several contemporary shipwrecks, to then conclude by reflecting on some particular aspects of the lessons learned throughout these years, and ways to move forward in the research of shipwreck timbers.

5.1 Selection of Trees for Shipbuilding

The analysis of structural ship timbers of shipwrecks from different periods allows us to infer information about timber procurement even when the wood has not been absolutely dated. Through the research of structural timbers regardless of their suitability for dendrochronological dating, we have learned that fast-grown oaks were selected for the framing timbers of several ships, namely Barceloneta I, Highbourne Cay, Emanuel Point II and III, Yarmouth Roads, *Bayonnaise*, and *Triunfante* (Figs. 1.5, 1.6, and 1.7). Most of the frames of *Magdalena* also fall into this category, although several slower grown oak framing timbers were also found in this wreck. All these ships were built (some presumably) in shipyards on the Atlantic coast between Ferrol and Bayonne (France), and since their chronology ranges from the fifteenth to the eighteenth century, it suggests that fast-grown oak trees were consistently preferred for framing elements throughout the centuries. However, the selection of trees for planks changes in this time frame. The hull planks of the three clinker-built ships investigated (Barceloneta I, Barreiros, and the Newport Ship) derive from old, slow-grown oaks, and were obtained most likely by radial splitting of the stem of the tree (Fig. 1.5). This is a pattern that is dominant in clinker-built construction throughout the Medieval Period in Northern Europe where splitting of the timber for the hull planks normally required straight-grained, old oak trees of the highest quality. At least one hull plank each from the Yarmouth Roads and Belinho 1 ships, both carvel-built vessels of suspected sixteenth-century date, were also converted radially from slow-grown trees but the majority of their hull planks derive from much faster grown oaks which had been tangentially converted. However, in the sixteenth century, the trees used for planking and framing elements in North Iberian shipyards appear to be consistently rather young and fast grown, with predominance of average yearly mean growth increments of 2 to 10 mm (see in Fig. 1.6 the graphs of the ships likely to have been constructed in the Iberian Peninsula from domestic timber, namely Belinho 1, Yarmouth Roads, Highbourne Cay, and Emanuel Point II and III in Fig. 1.6). The planking elements in these ships have been processed tangentially by sawing the timbers. This demonstrates a change in the woodworking techniques from the fifteenth to the sixteenth century, and suggest also an adoption of forestry practices meant to deliver a fast-turnover of oak wood (e.g. coppicing). In contrast, the wood used in the ships built in the same century in Italy (Delta II, Ribadeo) and possibly in the Northeast of France (Arade 1), derived from slow grown oaks (average yearly growth below 2 mm), indicating the existence of dense forests in the supply areas. The planks found in those shipwrecks had also been processed tangentially by sawing. In the eighteenth century (we lack data from the seventeenth century to make inferences), the wood used appears to be more diverse, both in growth rates and species (the hull of the *Triunfante* is made of pine) (Fig. 1.7), but the planking elements continued to be processed tangentially by sawing the timbers, regardless of the species. In this century, there was a great diversity of species available at the Royal shipyard of Ferrol (Trindade et al. 2020). We have also encountered pine in framing elements and

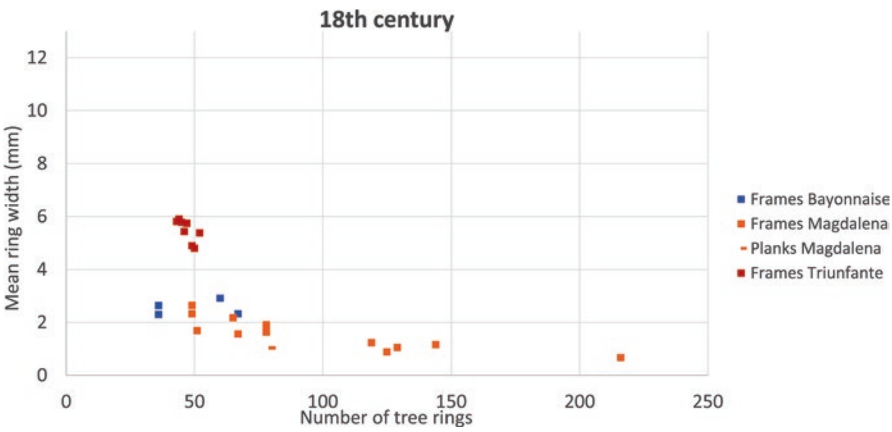

Fig. 1.7 Scatter plot of mean ring width against ring count for studied oak shipwreck timbers from eighteenth-century ships *Bayonnaise*, *Magdalena*, and *Triunfante*

ceiling planking of *Magdalena*. However, we cannot discard those elements as repairs, although archaeological and historical research suggest that the pine hull planks from *Triunfante* correspond to later repairs in the Royal shipyard of Cartagena (Pujol i Hamelink et al. 2013).

The use of young, fast-grown oaks for both hull planks and framing timbers in sixteenth century ships has been observed by archaeologists studying other shipwrecks. Such is the case of the *San Esteban* (wrecked 1554) seen on display in or stored at the Corpus Christi Museum of Science and History (Arnold and Weddle 1978), those of the early-sixteenth century Studland Bay wreck where only 17 of the 189 timbers assessed were suitable for dendrochronological analysis (Hamilton and Tyers 2011), and those of the Western Ledge Reef wreck (Bojakowski 2011, 2012). The data are not sufficiently well-replicated or consistent to argue for very limited samples taken from the surviving timbers of a systematic use of cohorts of trees of tightly controlled age, as Loewen has suggested for the framing of the Red Bay wreck (c.1565) or the “transitional” Cavaliere-sur-Mer vessel (c.1479?) (Loewen 1998; Loewen and Delhaye 2006). A pattern of the use of young, fast-grown oak is however emerging. Does this shift in timber selection, apparently coincident with the shift in shipbuilding technology from clinker to carvel, have a causal link? Addressing this question requires more data on timber selection, greater dating precision for these important ship finds, and a more considered study of the use of saws both in the conversion of tangential planking for shipbuilding and in contemporary crafts such as timber-frame construction of buildings. Can we begin to see a change in Iberian forestry practice during this period which is specifically designed to deliver the ideal product for shipbuilding in the most efficient time frame, as Loewen has suggested? The Arade 1 ship, likely built in the French Atlantic coast, is constructed from an homogeneous group of French timber (Domínguez-Delmás et al. 2013) with many of the trees employed for both planking and framing timbers over 100 years old when felled. The Ribadeo vessel comprises very substantial timbers (it is a much larger ship than the others studied from this century and specifically military in design), derived from oaks of rather variable age but including some trees over 200 years old when felled. The historical evidence suggests that this timber was sourced from Italy and around the Adriatic (see Chapter 4, Vol. 2). Seeing the selection (and even management/cultivation) of trees for shipbuilding in context requires a regional, even local, perspective, e.g., Iberian/Cantabrian/Biscayan situated in a European sphere of influence (see Chapter 6, Vol. 1). Just as we may glimpse a specifically Cantabrian forestry/shipbuilding interaction in the sixteenth century rather different interactions are evidenced elsewhere. The Drogheda boat, built in Ireland between 1525 and 1535 and repaired between 1532 and 1560 was constructed in the old clinker method with radially split oak planking (Schweitzer 2012). A few decades later, the armed merchantmen now labeled the Gresham ship, was built in carvel fashion from very old (150 years +) oak trees on the East coast (probably Essex) of England (Nayling 2014).

Our evidence for the eighteenth century is perhaps too sparse to make sustained comment (Fig. 1.7). As always, more data would be welcome. The information from *Bayonnaise* is limited to four framing timbers from the same, relatively small section of hull. The oak framing timbers of the *Triunfante* appear consistent in both age structure (young trees) and fast growth in contrast to the timbers from *Magdalena*, which are apparently derived from young through to very old trees.

5.2 Dendrochronological Dating of Iberian Shipwrecks

Our results illustrate the challenge of dating timbers from shipwrecks made of wood from areas where a dense network of long, well-replicated reference chronologies is lacking, such as the Balkans, Italy, or the Iberian Peninsula. Most samples of the Arade 1, Delta III, and Punta Restelos shipwrecks and some barrel staves from the Delta II could be dated because the wood originates from areas in Northern Europe with a long tradition of dendrochronological studies. However, dating three timbers from *Magdalena* indicates that we are heading in the right direction in the development of such reference datasets for the Iberian Peninsula.

Still our dating success is very low (only 15% of oak samples have been dated in total), which could be due to different reasons. First of all, it must be noted that although tree-ring analyses were carried out on hundreds of timbers, the majority of these had significantly fewer rings than the number traditionally recommended (e.g., 100 given by Baillie 1982), as series of such length provide statistically sound results when compared with the right chronologies. This minimum number of tree rings can be lower in certain circumstances (e.g., Billamboz 2008). Still, other samples containing more than 200 rings remain undated. Another reason for this could be that some of the new reference chronologies were not developed in the exact areas mentioned by historical sources (Domínguez-Delmás et al. 2020). Those areas are mostly located by the coast (Casado Soto 2006), where currently old-grown oaks are no longer to be found. A third possibility is that the growth patterns in the samples collected do not reflect the growing conditions of the trees that have been included in the reference chronologies. For example, if branches were used for framing elements it is likely that their growth patterns differ from the main chronology obtained from stems. Or if forked or twisted trees were selected for compass timber, it is also likely that their tree-ring patterns are distorted, hampering crossdating with the reference chronologies. This would also explain the lack of internal correlation between samples of the same shipwreck, although such a lack of matches between samples could also be the consequence of the trees for the same ship being sourced in different geographical areas, as historical documents demonstrate for ships such as *Magdalena* (see Chapter 9, Vol. 2) and *Triunfante* (Pujol i Hamelink et al. 2013). Finally, the possibility that the researched shipwrecks may not correspond to Iberian-built ships cannot be overstated. As presented above, research in historical archives regarding the Ribadeo shipwreck suggests that the ship may have been the *Santiago de Galicia* galleon, built in Naples in the early 1590s (see Chapter 3, Vol. 2). Similarly, the Delta II has been identified as an Italian ship (Ridella et al. 2016) and the Delta III as a Dutch merchant vessel (González 2017).

5.3 Sampling Strategy

Having a concerted timber sampling strategy is a requisite for obtaining a dendrochronological return on the archaeological investment. Shipwrecks are the remains of complex machines, that are themselves the result of complex networks of timber acquisition and conversion. In the decade of research presented here, however, we were not always the ones carrying out the sampling. Some of the shipwrecks discussed above exemplify the importance of having a well-planned and executed strategy, and played a crucial role in the development of the sampling protocols (Rich et al. 2018a) and guidelines (Domínguez-Delmás et al. 2019) that are now taken as the standard to interrogate shipwreck assemblages. Some lessons learned regarding the sampling strategy are summarized here.

As demonstrated by the case of the Punta Restelos wreck, samples should be attached to the wreck rather than detached or freely floating near the wreck site. Without substantial further investigation, there is no way of knowing if a loose timber came from the wreck under investigation or a different wreck nearby. Taking "opportunistic samples" from a site may yield promising data, but without archaeological context, it has no meaning.

Tree rings can still be seen and measured in samples containing galleries of *Teredo navalis*, but samples full of galleries often break, and chances of obtaining long, continuous tree-ring series are lost, as illustrated prominently by the *Bayonnaise*, but also by other shipwrecks. Therefore, sampling campaigns should target samples in parts of the timbers where the damage by *Teredo navalis* is less severe or, ideally, absent. In this way, the chances of furnishing several timbers suitable for dendrochronological research will increase, thereby increasing the chances of successfully crossdating the timbers within the site and with reference chronologies.

Sampling of the Barceloneta shipwreck was constrained by the desire to retain the integrity of timbers through documentation and conservation. Unfortunately, this limited the amount and quality of data that could be collected. Having observed cross-matches between some planks and between some frames could indicate that each of those groups represents a homogeneous cohort, maybe originating from the same area (e.g., frames were sourced from coastal, fast-grown oaks, and the planks from inland, slow-grown trees). However, this observation could only be confirmed by the sampling of more elements of the shipwreck. Musealisation is not incompatible with the sampling of ship timbers, as illustrated by the Viking ships in Roskilde and, more recently, by the dendrochronological research carried out in the Bremen cog ship (Belasus and Daly pers. comm) and the Batavia shipwrecks (Daly et al. 2021). Close collaboration between dendrochronologists and conservators can result in an extensive sampling of a shipwreck in display that is barely visible to both trained and untrained eyes.

Magdalena exemplifies an appropriate collection of samples, where a wide variety of approximately 20–30 timbers were targeted on the basis of (i) the timber element (i.e., frame, plank, strake, etc.), (ii) tree type (conifers and dicotyledons, for example, which can be differentiated underwater), (iii) presence of bark or sapwood, and (iv) if possible, ring count (a visual estimation is also possible even under water if the transverse section is exposed). High ring counts (over 80) have a greater probability of being crossdated with a reference chronology, thereby providing both a *terminus post quem* and a location, or the year (after which) and place (near where) the parent tree was felled. Greater precision in space and time can be achieved if samples retain bark or at least sapwood, which is often the case as seen with almost all the shipwrecks. A variety of tree types also increases the odds of being able to crossdate with existing chronologies, especially for oak and pine, and because some species have limited growth distributions, they can also be useful in provenancing the timber. Even if crossdating proves impossible, sampling from a variety of places on the wreck, from a variety of structural timbers, also provides valuable information about what kinds of trees (species, age, growth rate, etc.) were sought by shipwrights for certain architectural functions.

At this point, a caveat must be provided, especially in regard to targeting samples with many rings. This is an appropriate strategy only if ascertaining the date and provenance are the sole objectives. If research questions are broadened to include those relating to the types of timbers sought for certain elements, forestry practices, etc., then seeking only timbers with large numbers of growth rings will introduce bias into the samples. From the samples collected from the Yarmouth Roads, only one had more than 50 rings, which indicates that most of the structure was built with very young trees. Crossdating of short series is extremely challenging (Domínguez-Delmás 2020), but novel approaches such as tree-ring dating based on stable oxygen isotopes have proven successful in other areas (Loader et al. 2019) and may hold the key to date these types of timbers in the future.

Finally, the implementation of a sampling strategy will be all the more successful if it is achieved within the context of a multidisciplinary research program, as exemplified by the *Ribadeo*. As already stated, the lack of context hampers the interpretation of facts, while the integration of multiple disciplinary approaches (archaeological, historical, and dendrological) to the investigation of wreck sites can yield extraordinary results.

5.4 Use of Novel Approaches for Provenancing

The ForSEAdiscovery project has been a major promoter for the development of reference datasets and the exploration of novel techniques to provenance timber from shipwrecks (Domínguez-Delmás et al. 2020). The possibilities of using strontium isotopes to provenance cedar (*Cedrus* sp.) shipwreck timbers had already been tested in the Mediterranean by Rich et al. (2012, 2015, 2016), but the method was taken a step further with the in-depth study by Hajj (2017) who demonstrated that the isotopic signal of (sea)water prevails in waterlogged wood. These results were also attested by Van Ham-Meert et al. (2020), with the conclusion that due to diagenesis occurring in waterlogged wood, the original strontium isotopic ratio of the timber prior to submersion cannot be determined, and therefore, strontium isotope analysis is not a reliable method to provenance submerged shipwreck timbers.

The suitability of using the organic compounds in wood for wood identification and DNA for wood provenancing has also been tested. The degradation of organic compounds in waterlogged wood is a major obstacle for the determination of the wood species based on chemical composition (Traoré et al. 2018). Similarly, the retrieval of long DNA sequences from ancient, waterlogged timbers is a challenge, but advances in DNA amplification methods are making it possible to obtain DNA from ancient and historical wood (Wagner et al. 2018; Linar et al. 2020). The resolution of current DNA methods to pinpoint the provenance of wood remains low, hence future efforts should further explore the potential of genetics to refine the origin of wood in combination with other methods (Domínguez-Delmás 2020).

6 Conclusions

This synthesis of dendroarchaeological research on Iberian ships and timber selection identifies shifts in patterns of timber use, especially during the period of technological change from clinker to carvel construction in the fifteenth to sixteenth centuries. The relationship between these technological innovations, the adoption of different methods of timber conversion, and possible developments in woodland management pose a research challenge that requires not only more data but a consilience between archaeology and history. Can we see attempts at centralized oversight of forestry practice and woodland exploitation during the Early Modern Period in Iberia reflected in the type of timber employed in the shipwrecks we discover? Arguably, the dataset presented here is biased toward ships employed in explorations, expeditions, and private mercantile or fishing enterprises. A more balanced view might be achieved through examination of more shipwrecks of military vessels and those associated with the highly controlled activities of the *Carrera de Indias.* Equally, the sampling strategies we advocate need to be employed more widely so that we might compare the nature of timber usage in Iberian shipbuilding with adjacent regional industries especially on the Atlantic façade.

The absolute dating of Iberian timber found in shipwrecks remains a challenge. Continued development of Iberian ring-width chronologies for the Early Modern Period, particularly from areas known to have been exploited for timber shipbuilding, is a long-term and necessary project which will deliver benefits in refined dating of parallel timber industries such a vernacular, urban, ecclesiastical, and palatial architecture. For those ships built from young, and possibly highly managed, oaks we will need to develop alternative approaches, probably focused on harnessing recent refinements in radiocarbon and isotopic dating.

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Chapter 2
Hauntography of an Ordinary Shipwreck: Paradox, Appellation, Provenance, Apparition

Sara A. Rich

Abstract Nautical archaeology frequently shies away from theory in favor of praxis, a tendency that has been criticized as hindering the development of a middle-aged archaeological discipline. This paper applies a recent philosophical movement, object-oriented ontology, to the study of ships and shipwrecks in order to address commonly encountered, and overlapping, issues of mereology, identity, origins, and representation. It takes as its example the Yarmouth Roads Protected Shipwreck, of presumed Spanish origin wrecked in English waters, to exemplify how an embracement of the paradoxes intrinsic to shipwrecks as objects (collections and souvenirs) can result in new ways of representing and relating to them.

> Being-in-the-world means living inside shipwreck. …
>
> The wetness of the encounter, the brute physicality of shipwreck, won't let us understand causes. … The only stability is on the sea floor, but that distant space is also a churning site of sea changes fast and slow.
>
> A shipwreck ecology, however, needn't be a place only of horror or nostalgia. There's ecstasy in the waters too. Not the relief of having survived or the satisfaction of figuring it out: those things don't last. But an intellectual tingle that ripples out into the physical world, a willingness to confront the inhumanity of our environment, and an appetite for experience that doesn't mind getting wet. That's the direction named reality. (Mentz 2014: 8).

1 Paradox

As objects of transposition, ships and boats literalize metaphor: *meta* (across) + *phorein* (carry). A fleeting moment, a naval fleet, both have etymological origins in the Old English *fleotan* (to drift, float, or flow) – the object is inextricable from its method of temporal-spatial passage. Ships may be the ultimate objects of mobility, but what about shipwrecks, who are ships that have failed in their singular task of carriage? While we speak of ships as transporters, mediators,

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and connectors, like other tools, once they break, they are disposed of and become forgotten rejectamenta; they are cast out of the human-social sphere (Lucas 2005; Harman 2010; Olsen et al. 2012). And yet when we archaeologists examine them, we go to great lengths to reinstate their 'authentic' socio-cultural statuses, perhaps at the expense of divulging the ontology of the object itself (Alberti et al. 2011). No thing is just "an aspect of human intelligence and culture" (Malafouris and Renfrew 2010). Indeed, such a humanocentric stance is problematic for ethical reasons as well: "The central position of *Homo sapiens* in landscape studies, to the detriment of the study of the roles played by animals and plants – and increasingly also by non-living elements of the world such as climate, soils, rivers, mountains, and, indeed, the sea – is no longer considered fitting for a more ethically conscious era, where animal welfare, tree preservation, and landscape protection have become embedded in everyday life" (De Noort 2011). The role of nonhuman agents in maritime history was outlined in the mid-1980s (Law 1986), and later on, Dolwick (Dolwick 2008, 2009) began a deanthropocentric study of steamboats using Actor-Network Theory and redefining "social" as "associated." Ships and shipwrecks make for particularly suitable channels with which to think through the ontologies of objects, in part because of the paradoxes associated with their behaviour (Cohen 2015).

The recent movement in metaphysics, object-oriented ontology (OOO, at the forefront of much recent posthumanist and new materialist thought), posits that reality is composed of objects – not, as Enlightenment-era thinkers would claim, that reality is composed of relationships between being and thought: e.g., Kant's tensions between human and world, or Descartes's rift between mind and body. Besides its most basic premise of de-anthropocentrism, this movement also shamelessly confronts Aristotle's Law of Noncontradiction by stating that objects are riddled with paradox. Drawing from the phenomenologies of Husserl and Heidegger, OOO-adherents claim that "An object is both a vigorous, consistent unit with real qualities, and yet at the same time completely withdrawn from all of its composite relations, elements, qualities and parts" (Harman 2010; Jackson 2011; Morton 2013). Few objects exemplify their paradoxical state as much as shipwrecks; yet, let us begin with ships, as they manifest plenty of their own paradoxes which will relate to those of their eventually wrecked alter egos.

We can first take the example of the mythical ship of Theseus, the subject of popular philosophical thought experiments in Classical Greece. The paradox is this: If, over time and many sea ventures, the ship of Theseus gradually had each and every timber of its hull replaced, is it still the ship of Theseus? The paradox addresses questions of identity, origin, sameness, cultural constructs, and even multidimensional time-space paradigms, which is why there will never be a single answer that will satisfy all who ask. That being said, the object-oriented philosopher or archaeologist, would say that it is indeed the same ship: All objects (ships) are made up of other objects (timbers), but no object (ship) can be reduced to its parts (timbers), so all objects (ships) are independent of their parts (timbers) (Rich 2017). Philosopher Levi Bryant explains, "The larger object composed out of these parts is another object that has its own autonomy and life. If this is the case, then it is because parts of an object can come and go, while the object remains."[1] The rotting and replacing of timbers experienced by the ship of Theseus (or any other ship) is no different from the replacement of dead and dying cells and microorganisms in our bodies: like ships, we are holobiontic, hosting great populations of microbes and other outsiders, communities composing an individual. Somehow, the communities can come and go, yet the individual remains. This paradoxical solution to the paradox at hand is called "strange mereology," after the study of relationships between wholes and parts (Bryant et al. 2011).

In another example of strange mereology, Ian Bogost (2012) describes a cargo ship: "The container ship is a unit as much as the cargo holds, the shipping containers, the hydraulic rams, the ballast water, the twist locks, the lashing rods, the crew, their sweaters, and the yarn out of which those garments are knit. The ship erects a boundary in which everything it contains withdraws within it, while those individual units that compose it do so similarly, simultaneously, and at the same fundamental level of existence."

His choice of a container ship to illustrate the concept of strange mereology is not arbitrary. A container ship is a self-contained collection: "The confines of a ship are analogous to the covers of a book or codex as demarcation of a locus as sense making" (Deleuze and Guattari 1998; Blackmore 2002). While texts have the capacity for mobility, a ship is a self-contained collection on the move. It negotiates that what is contained and what is boundless: the sea. In her much-cited work on collections and souvenirs, *On Longing*, Susan Stewart (1984) writes that: "[T]he archetypal collection is Noah's Ark, … a world which is representative yet which erases its context of origin. … While the earth and its redundancies are destroyed, the collection maintains its integrity and boundary. Once the object is completely severed from its origin, it is possible to generate a new series, to start again within a context that is framed by the selectivity of the collector. The spatial whole of the collection supersedes the individual narratives that "lie behind it.""

This assertion is in line with object-oriented thinking regarding integrity and mereology. However, where Stewart says that the collection is representative yet "erases its context of origin," there is a slight rift in that the ship is both a collection and a souvenir, intrinsically linked and psychically connected with home – land (Rich 2017). At sea, everyone is a visitor, passing through a liminal, transitory state, end route. The ship is a collection of various objects, yes, but it is also a souvenir, perhaps the passengers' most important souvenir as the ship does its best to mimic home, with walls, floors, and chambers that move across the surface of water, where we do not belong.

In this sense, the direction of travel is irrelevant; yet, the ship has a greater tie with the port it just left than the one anticipating its arrival. Even as objects in perpetual motion, we are always closer to our origin than to our final destination,

[1] Bryant (2010): Blog: Larval Subjects: https://larvalsubjects.wordpress.com/2010/05/01/three-strange-mereologies/

simply because the latter is unknown, unconnected. So Stewart's "context of origin" cannot really be erased.

Likewise, if the ship-collection is taken apart, the objects composing it are also still tied to their origins. Stewart claims that "the selectivity of the collector" (in this case a shipbuilder or ship architect) makes it possible for the collection (the ship) to "supersede the individual narratives" of the souvenirs composing the collection (ship timbers, cargo, crew, etc.). OOO-adherents would counter that by claiming that neither the narrative of the ship as a whole nor that of its components can supersede the other. Each object narrative represents a different ontology and thus exists on equal grounds, whether one considers those grounds as "flat" (De Landa 2002; Bryant et al. 2011), "symmetrical" (Olsen et al. 2012), or "voluminous" (Steinberg and Kimberley 2015). Object complexity does not validate hypothetical existential hierarchies; in other words, the human object is not championed over any other, neither the collection over the souvenir. Likewise, our relationships with other objects are no more or less intrinsically important than relationships that don't involve humans at all.

An object-oriented archaeology of a shipwreck would level the existential hierarchy between captain, mast, amphora, ballast, swab, cannon, keel, porthole, and hull. Each of these objects has its own reality, its own ontology, and instead of seeing them solely within a socio-cultural (read: human) domain, or as elements within a relationship or network, an object-oriented nautical archaeology would recognize that relationships are only one aspect of an object's ontology because an object cannot be defined by its relationships with other objects: essentially, all objects are withdrawn, antisocial (Harman 2010, 2011). The second aim of an object-oriented nautical archaeology, as explained earlier, would acknowledge and accept the paradoxes inherent in studies of all objects, with ships, and shipwrecks even more so, paramount in exemplifying contradiction.

An example of this complex of contradictions and dismissed ontologies is that of the enigmatic "Iberian" ship. Plaguing the nautical archaeologist are questions of how to identify an Iberian ship, what aspects of Iberian shipbuilding are unique to the peninsula, and whether or not a distinct, characteristic Iberian shipbuilding tradition existed during the Early Modern period (Oertling 1998; Castro 2008; Rich et al. 2018). Traditionally, nautical archaeologists have posed these questions in the hope that if any of them could be answered conclusively, then it would become much easier to attribute shipwrecks of this period (located globally) to either an Iberian shipbuilding tradition, or to another tradition hailing from beyond the peninsula, however its confines are defined. However, from an object-oriented perspective, there are some problems with this approach and its underlying assumptions, namely those of (cultural or national) identity, representation, and origin. With an object reorientation though, these issues can be either resolved or rendered moot (Table 2.1).

As Baudrillard wrote, there is a notable ontological difference between provenance, and identity and representation (Baudrillard 2005). Identity and representation are forms of authentication, layers of social meaning shellacked onto the shipwreck by the human ventriloquist. Yet by insisting that the shipwreck serves

Table 2.1 Traditional problems in nautical archaeology reconsidered through the lens of object orientation

Issue	Paradox: Traditional nautical archaeology	Solution: Object-oriented nautical archaeology
Identity	Identifying a ship as Iberian first requires having a solid definition of Iberia. We usually think of Iberia as the peninsula composed of the modern nations of Spain and Portugal. So a ship built in a Portuguese or Spanish shipyard would be Iberian. But what about a ship built in Naples, Ceuta, or Melilla, which were under Iberian dominion but were not Iberian geographically (or culturally)? Or what about a ship built in The Netherlands but commandeered or purchased by the Spanish or Portuguese navy? Or one built in Lisbon by Ukrainian carpenters?	A ship is independent of the flag under which it sails. A ship is not nationalistic. It doesn't care where its crew came from or which language they're speaking, or where the captain lives. Therefore, calling a ship Iberian, or not Iberian, doesn't really get one any closer to divulging its autonomous reality.
Representation	The ship's port of origin might not have that much to do with the identity of the ship when it sank. Yet, the characteristically fluid nature of ships and shipping is often overlooked so that maritime historians can provide a convenient label identifying a ship as representative of a people (Harpster 2013). Given the notoriously diverse origins of the ship's components, from multi-ethnic crew members and cargo units to the various sources of the raw materials composing it, how can a ship represent a singular people, or even a singular tradition?	A ship is not representative of "a" people. It is not representative of people at all, any more than it is representative of forests, geography, water conditions, economies, climate, technologies, and the innumerable other historical and geological circumstances of its reality. The ship itself is more than the relationships of which it is an element, more than the elements it encompasses and comprises, and more than the conditions of which it is a product. It can only really be representative of itself – it represents its own reality, no more, no less.

(continued)

Table 2.1 (continued)

Issue	Paradox: Traditional nautical archaeology	Solution: Object-oriented nautical archaeology
Origins	Perhaps the "authentic" identity of the ship could be reinstated by sourcing the woods it was built from back to their forests using various techniques of dendroprovenance. However, like the ship of Theseus, a typical wooden vessel underwent several phases of repairs before it either sank or was rendered irreparable and repurposed for scrap. Repairs were commonly opportunistic; that is, the repairs could be done at the nearest dockyard, not just the one where it was first built. Therefore, it's likely that wood used to build a ship would represent a great number of forests – not just the ones that furnished the original timbers. Repairs also would have been made using whatever joining technology was favored at that dockyard, or by the carpenters doing the repairing. So neither the joins nor the timbers may necessarily point to an origin for the ship. So is provenance futile?	Like the number of flags flown or the languages spoken onboard, no matter how many repairs a ship experiences, its timbers replaced with new (foreign?) woods, it's still the same ship. Wood from repairs is no less integral to the ship's way of being than timbers intact at its first launch. Therefore, provenance is one of the more worthwhile endeavors in an object-oriented nautical archaeology. The timbers guide the archaeologist along the narrative of this object, both as collection and souvenir. As mentioned above, in contrast to Stewart's (1984) "context of origin," object origins are indelible. No matter how long a shipwreck has been carrying out its existence under the sea (decomposing, eroding, and doing whatever else it's busy with down there), it is still intrinsically and metaphorically linked with the land(s) whence it came.

human accessibility, we are not doing ourselves any real favours (Olsen et al. 2012). We want to learn about the wrecked ship, but trying to squeeze it into a human construct, like a socio-cultural pareidolia, could be an exercise in vanity – literally. These exercises tell us only about ourselves – our preoccupations with cultural identity and social representation, and tautologically, our human selves. By contrast, provenance is an important step toward "ontography" or allowing object realities to reveal themselves via interaction through collocation, as described by Bogost (Harman 2011; Bogost 2012). An ontograph of a shipwreck, for example, could include provenancing the Thesean ship timbers, which act as souvenirs in the being of this complex traveller, and it would continue to draw as complete a picture as possible of the ship's unique way of being as a sailing vessel and a wreck, without resorting to the arbitrary labels of national identity and stylistic representation. Although "object-fixation" in nautical archaeology is seen as a bad thing (Törnqvist 2013), it is exactly an object-oriented approach to rotting ship timbers that can make these objects relevant to the humanities and social sciences, among others.

Defending why archaeologists do what we do has become the economic norm, and the normal way of doing so is to bring the materials back to the culture (Webmoor and Witmore 2008; Fahlander 2012). Networks of exchange, phenomenologies, materialities, all these approaches are efforts at re-culturalizing things that have been de-culturalized; shipwrecks, like other abandoned archaeological objects, exist on their own, antisocial and independent of the human gaze. They are withdrawn. On the other hand, it seems that object-oriented philosophy was practically made for archaeology, especially the underwater kind (Olsen et al. 2012; Cole 2013, 2015; Pétursdóttir 2013; Normark 2014). Ontographs are inherently "messy," and like Bogost metaphorizes, "An ontograph is a landfill" (Bogost 2012). So what better way to approach the paradoxes of nautical and other archaeologies and their objects, buried under stratigraphies of time, geological processes, organisms, rubbish, grass, mud, sand, water? Bogost even closes his manifesto by describing an archaeological sense of wonder at objects in a messy heap, and by imploring, "Let's go outside and dig in the dirt" (Bogost 2012). Ontographic processes could produce more meaningful ways of relating to what's down there. A shipwreck ontograph would not be linear like a biography, or topographical like a map; it would not be ordered like a site plan, or act as a window to another dimension like a trompe l'oeil (Adams 2013); it might be all or none of those things, but it would relay, somehow, the way it might be to be that shipwreck (Figs. 2.1 and 2.2).

2 Appellation

Under 6 m of water in the Solent, the strait that separates the Isle of Wight from the mainland UK, there is a shipwreck. She's a shipwreck that might or might not ever rewrite history, although she has been deemed important enough to be designated as the Yarmouth Roads Protected Wreck Site, and a 50 m exclusion zone has been established around her perimeter (Fig. 2.1). The shipwreck at Yarmouth Roads was first excavated in the mid to late 1980s, when she was determined to be an armed merchant carrack dating to the mid-sixteenth to early seventeenth century, based on ceramics and metal typologies (Watson and Gale 1990). Excavations produced pewter tableware from The Netherlands, Italian pottery, fine bone combs, and a bronze pestle, representing pieces of cargo or personal items of the crew. Near the site, a bronze Alberghetti cannon was recovered, although its connection to the shipwreck assemblage is hypothetical. This array of objects suggests that the 30 m long merchant vessel had been engaged in trans-European trade at the time of her sinking (Watson and Gale 1990).

From the predominant iron joints used in the vessel's construction, the ship is supposed to have issued from a Mediterranean shipyard. Excavators draw a comparison between this shipwreck and the Levantine Spanish armada wrecks based on her iron fittings, size, and structure, suggesting "a large, full-rigged ship contemporary with vessels termed carracks and galleons" (Watson and Gale 1990). This comparison has lent itself to a popular assumption of the wreck as Spanish. While the excavated contents seem to point to a largely Mediterranean cargo, when the vessel wrecked, she would have remained exposed far above the shallow waters, so these artifacts cannot be seen as representative of the cargo because of differential effects of contemporaneous salvage operations, such as those frequently conducted by the Isle of Wight's resident privateer, Sir Edward Horsey (Watson and Gale 1990;

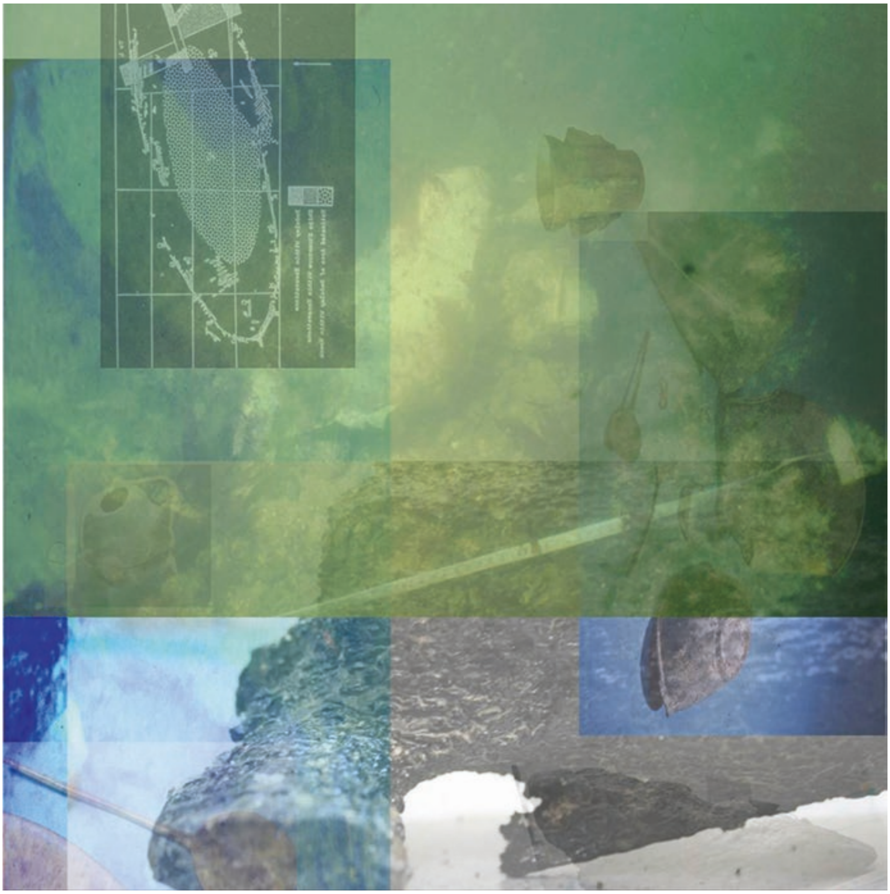

Fig. 2.1 *Yarmouth Roads: Hauntograph 1* explores the semi-circular processes of dislocation experienced by parts of the shipwreck as artifacts are removed from the site, and samples of hull timbers and fittings are cut away. At the same time, there is exchange; items such as datum points, scaffolding, and tape measures are left like offerings on the seabed. (Author, 2016; individual images courtesy of the Maritime Archaeology Trust and the Isle of Wight Museum Services)

Fenwick and Gale 1998; Dunkley 2001). Archival research in the High Court of Admiralty Records produced a reference to the *Santa Lucia*, a Spanish ship carrying a cargo of wool to Flanders in 1567, and that "by fortune p[er]ished and was lost in the seas thwart of Yarmouthe in the Isle of Wighte" (Fenwick and Gale 1998). Since the discovery of this reference, the shipwreck at Yarmouth Roads and the *Santa Lucia* have become practically synonymous (Dunkley 2001; Plets et al. 2008). Yet identifying the Yarmouth Roads Protected Shipwreck as the wrecked *Santa Lucia* is a logical oversimplication – the initial assumption of the shipwreck as Spanish is already conjectural, so a link with the *Santa Lucia* cannot be more than tenuous, circumstantial. This name is no more closely linked to the vessel than is the

Fig. 2.2 *Yarmouth Roads: Hauntograph 2* imagines a Gestalt relationship between the sailing vessel, its wooden wreckage, and the archaeological samples thereof. Examining this relationship helps to conceptualize why it is necessary to challenge the popular (and academic) notion of shipwrecks as dead ships. (Author, 2016; individual images courtesy of the Maritime Archaeology Trust and the Isle of Wight Museum Services)

Alberghetti cannon. As in the issue of national identity described above, the supposed link between the historical and archaeological accounts does not add much to our knowledge of the shipwreck (Ahlström 1997). What this scenario does demonstrate is the distinctly human need to name things. We cannot just let the shipwreck be anonymous; her public and, unbelievably, scientific relevance is assumed to be much greater if the ship's original name is reinstated, despite the fact that named or unnamed, the shipwreck and her assemblage are unaltered.

Eschewing anonymity is a feature unique to our species, especially our culture. We modern humans are so engrossed in being at the top of an existential hierarchy that for nonhuman objects to be considered worthy of existence, they must be hoisted up to our level (Marder; Bogost 2012; Adams and Rönnby 2013; Hocker

2013; Cole 2015). In order for an object to be taken seriously, it must be personified, and the easiest way to personify is to give it a name: we name hurricanes, pets, cars, boats, bicycles, plants, computers, … my grandmother's temperamental riding lawnmower was named Bertha. Naming things brings them closer to us, as in ownership, but it also brings them up to our level of sentience, acknowledging that they seem to have a mind of their own at times, and that they need to be reasoned with. And that acknowledged sentience, or cognizance, gives them greater importance.

But this shipwreck is not really any more important than any other. She's an ordinary shipwreck: mangled, eroded, overgrown, half-buried, half-eaten, half-looted, half-excavated, and unique. This underwater mess, this ordinarily unique landfill, is also no less deserving of existence (or research or protection) than any other shipwreck. Her name is ontologically irrelevant.

As described in the previous section, the name game is one of several problems related to identity and authentication in nautical archaeology. Drawn to compartments, categories and labels though we may be, ship identities were as fluid as the waters they sailed upon. Vessels were often purchased and repurposed under a different name, even in a different language. Archival references might identify a ship by the name she was "born" with or the one she "died" with, but in the meantime, or even at the same time, there may have been several others (Ahlström 1997). So reinstating a name is not necessarily the same as divulging who she is, where she came from or where she stopped along the way to face repairs, refittings, or requisitions. A ship can have many identities, each of them as authentic as the other. Though she may respond to acoustic battery from sonar mapping, she won't be summoned with name-calling, even if one of them is correct (Bryant et al. 2011). As goes the children's song, "Sticks and stones may break my bones, but words will never hurt me." But from the perspective of a shipwreck, the vulnerability of her sticks of frames and planks, and the weight of her stones of ballast and cargo, will break her into pieces, but insistence on a name could hinder putting those pieces back together again with integrity.

3 Provenance

A wooden ship is like a prodigal child of the forest; it goes astray and stays long away, but it is always more linked with where it's been than where it's going. When it wrecks, it sinks to the seabed, returned at last to the earth. Provenance is essential to ontography. But like identity, there is never just one origin. Ship timbers, both collections and souvenirs, have origins – not one, but many (Rich et al. 2018). The use of the singular would deny the complex ontologies of individual timbers, thereby abbreviating those of the ship. Timbers came from trees in forests that were felled and travelled along rivers or other routes to shipyards before being incorporated into a ship-collection. New timbers from other forests fitted in other dockyards combined with or replaced dead wood or dated architecture. Ships were forests transmogrified, shape-shifters skimming in and out of geographical frames of reference.

Shifting shape is one thing; shifting material is another. Wood keeps the ship honest, grounded by lignin and cellulose to its provenance of land, lest it forget its roots and become feral; the prodigal ship will always come home.

So far, the shipwreck at Yarmouth Roads has had timbers from her bow, stern, and starboard amidships sampled for the purposes of dendroprovenance. Underwater, the wood was difficult to saw through; it was tough oak infused with clay substrate that had resisted the hungry efforts of gribbles, piddocks, and teredos. Those samples are being subjected to all kinds of wood science analyses to see how they compare with datasets of living forests, who are likewise marked to their core by site-specific air, water, elevation, winds, soils, slope, seasons, or the lack thereof. Baudrillard (2005) says that time is embedded within the very fibres of wood; but time is not alone as space resides there too. Protean trees carry the mark of place with them even as they sail around the globe, even as they are sliced and their growth rings measured, their ratios of trace elements and stable isotopes calculated, their DNA extracted and amplified, their anatomy configured for special markers of that place, those origins.

There has been a recent philosophical backlash against trees as metaphors of existential hierarchies: that vertical arboreality doesn't sufficiently relay the multiplicity of planar existence, and that rhizomes would better take trees' place as the living metaphor for reality (Deleuze and Guattari 1998). Rhizomes may well be better suited to the abstract vagaries of this task, but metaphor switching cannot ignore the tree's place in the ecosphere, in the psyche, and in reality; furthermore, trees are not unidimensional ladders going up and down but physically dimensional objects composed of rhizomatic networks and inspiring an "apophatic hierarchy" (Siewers 2014). Our concept of matter stems from Aristotle's, which he named *hyle* (wood) after a tree's ability to transform reductively into smaller and smaller pieces infinitesimally (Marder; Ingold 2007; Harris 2014; Rich 2017). From forest tree to lumber downstream, to ship timber, to shipwreck element, to wood sample: dendroprovenance reverses this process, disrupts the vector force of a linear chronology, and anachronistically reconnects the infinitesimal with the origins.

Perhaps the laboratory analyses on the timber samples from the shipwreck at Yarmouth Roads will demonstrate affinities with wood from forests in Cantabria, Galicia, Andalucía, the Basque Country, or Portugal. That still won't make her an Iberian ship, and it still won't name her the *Santa Lucia*, but it would increase the number of infinitely possible elements making up the ontograph of this shipwreck, the revelations of interaction through collocation. If the ship's wood were linked with oak from The Netherlands or Poland, England or Canada, then the ontograph would change accordingly – it is a description that must remain fluid and allow itself "to become enriched by new influx" (Smith 2014). The ontograph is always a work in progress, another shape-shifter whose form depends on acquisition, interpretation, angle, and light.

4 Apparition

On the other hand, given the fluid and shape-shifting natures of forests, wood, and ships, developing a shipwreck ontograph could be an exercise in personal vanity, as any attempt toward decoding the way of being of an object is nothing but an intimate estimate. While ontography at least addresses the reality of nonhuman things (Olsen et al. 2012), the describer is embedded within the description, and the ontograph must always change along with what becomes accessible to the ontographer. But more is unknown than known, and more is changing than remaining – that is entropy. Shipwrecks were once described as the static seabed remains of a once dynamic machine (Muckelroy 1978; Adams 2013), but if that were true, there would be no rush in descending down there to them. A shipwreck is not a dead ship; though riddled with bodily metaphors it may have been (Blackmore 2002), its ontology continues, just in another form and place (Rich 2021).

Existing in their voluminously foreign, violet-black, murky green, and hyaline blue worlds (Alaimo 2013; Mentz 2014; Steinberg and Kimberley 2015), shipwrecks are notoriously isolated, secluded, really physically withdrawn from human accessibility. Shipwrecks are not present or absent, not dead or alive. They characterize a near ontological void, the lack of a sense of presence, which leads to a lack of perceived being – in Derridean terms, they exist hauntologically (Derrida 1994). In this respect, a "hauntograph" might still better address that tension in space (public and private, accessible and withdrawn) and the temporal tensions felt as we interpret and relay the bygone yet enduring (Cole 2013). Because even though the shipwreck does exist regardless of the human gaze, if we are its ontographers, we are limited to and by our access; so we can never really be ontographers but hauntographers instead (Rich 2021). Drifting materials in time, shifting forms in space, presence, like the present, is an apparition, *fleotan*.

> The gyred Atlantic scatters the enclosed Mediterranean, a whirl of flows for convoys. Current-crossed and relentless, the froth and flux of oceans bear shipwreck, effacement, a bare record of receding wakes, a cobbled fleet of appositions, words and things. (Cohen 2015).

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Chapter 3
Archaeological Perspectives in Galicia During the Age of Religious Wars: The *Capitana* and *Almiranta* of the Illyrica Squadron

Miguel San Claudio Santa Cruz

Abstract The particular position of Galicia on the Atlantic gateway makes its coasts suitable to collect archaeological remains from European History. During the religious wars that ravaged Europe in the sixteenth and seventeenth centuries, the Atlantic was the setting for some important episodes and several were conducted on Galician coasts. Two wrecks, among the biggest ships of its time are located and one of them is under study right now. The *San Jerónimo* and the *Santiago de Galicia* are two galleons that can provide us a view into the life of huge Spanish war galleons of the sixteenth century.

3.1 Introduction

The sea is the best way of communication that the human being has known throughout history. On the waves have ridden the ideas, technical advances and culture that has shaped the human planet as we know it. But the sea has also been the scene of the recurring human madness that makes the species itself its most fearsome enemy. If the transportation of human beings and goods is simple and fast by sea, so is the transfer of soldiers and their equipment. The wars that developed throughout the Early modern age had, for a global empire like the Spanish, spread over four continents, with an important maritime component. The coast of northern Spain, and more significantly that of the former Kingdom of Galicia, is located on one of the continental peripheries, away from the main European cultural axes. However, this position brings it closer to one of the most important communication routes that

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humanity has ever known and that runs along Galicia's juggled coasts (González López 1985). These routes also connect the Iberian façade with the twin Finisterres of Cornwall and Brittany, within less than 5 days of navigation, in the sailing conditions of late sixteenth century. Control of this sea route will be essential for any power seeking to dominate the ocean. Global navigation, from the end of the fifteenth century onward, further increased the importance of this continental vertex, which dominates the transit from northern Europe to practically the rest of the planet. This area was the stage of successive war conflicts, from the fall of the Roman Empire to the Second World War.

The ease of communication configures the Bay of Biscay as a kind of Mediterranean, with multiple relationships and influences that we can trace back to prehistory (Cunliffe 2019). The geostrategic situation of Galicia explains its importance in the war that, facing the Atlantic, had its main land component in the Flanders area. This coast became a kind of war front from which supports and supplies left toward the north. In addition, it was an important base for the successive offensives led by Spain and Portugal in support of the rebellion on the British Islands in the reign of Elizabeth I. This privileged relationship with northern Europe meant that these coasts were always plunged directly into every conflict, with consequences that were often devastating, for the coastal communities facing this sea. In Galicia this situation was particularly difficult from 1580 until the signing of the peace in London in 1604 (Frías 1972).

The risk of being so close to the enemy coasts led to the abandonment of large coastal areas, the reduction of sailing and fishing activity, but it also brought about the military development of the kingdom with the development of a naval base in the estuaries of Ferrol—La Coruña, the fortification of coastal enclaves, and the establishment of a delegated political structure at La Coruña with a General Captain, and president of *Real Audiencia del Reino de Galicia*.

From the moment in which international policy turned its back on the Mediterranean and set its goal on the globalization offered by oceanic navigation, the coasts of Galicia and the port of La Coruña–Ferrol became a fundamental point for King Felipe II control over the Atlantic Ocean. The importance acquired by the port of A Coruña and its hinterland ensured that its development was sought from the crown. Attempts were made to turn La Coruña into a port for the spice trade, and the Royal Audience was established in 1563, whose owner also held the position of Captain General, the highest military rank in the Kingdom of Galicia. The clear objective was to promote the development of a city from which to exercise dominion over the Atlantic trade route, following the steps that led the Romans to establish the port of *Brigantium* in the same place a millennium and a half before. Thereafter, the city, a consolidated port for transit through the Bay of Biscay since medieval times, reached its maximum military development and was reinforced with enhanced defenses after the defeat of the 1589 Drake and Norris Contra Armada before its walls.

3.2 An Armada's War

As mentioned above, the measures implemented by Spain to allow the control, protection, and security of maritime traffic, as well as the military empowerment of the Galician coast made the territory a military target. If before Galicia suffered sporadic attacks, typical of the activity of pirates and other undesirables, from the reign of Felipe II, Galicia became the most accessible point for North European enemies to "singe the beards of the Spanish king" in their own territory. Soon the most exposed points, such as the islands, the site of religious hermits, were abandoned after successive attacks "by Lutherans" (González-Alemparte Fernández 2003), while navigation and fishing become increasingly unsafe. To counter these attacks, the most exposed harbors and anchorages were equipped with artillery and other measures for self-defense.

Jean de Glamorgan, a French admiral, was the commander of the first Navy to attack Galicia in 1543. This attack was stopped at the battle of Muros in what has been defined as the first modern naval combat, in addition to being the baptism of arms of what would be the best Spanish admiral of all time: Don Álvaro de Bazán, first marquis of Santa Cruz.

Many other campaigns were developed from 1580 onward, turning Galicia into a battlefront against Protestantism. Galicia was in a state of war until the London Treaty of 1604 witnessing numerous assaults and counterattacks. Beginning in 1588, with the lessons learned from the Armada of that year, Galicia will become the main base from which to project Spanish power to northern Europe. The Atlantic wind regime demonstrated the inappropriateness of choosing Lisbon as a starting point.

The Galician ports proved to be the most suitable for receiving and projecting naval force. This meant expanding supply lines from Andalusia and profiting from the proximity to the northern steel mills and shipyards. The deployment of Armadas from Galician ports required a broad logistical effort of supply, services, and accommodations, concentrated in the ports of Ferrol and La Coruña, organized by a bureaucracy and led by the captain general of Galicia, his officers, and the commanders of the Navy.

3.3 The Archaeological Record

The war effort developed from Galicia and the response of the Protestant forces, generally English, generated an important archaeological record currently under study. Although this record is not only found underwater, at this time we will focus our eyes on those sites that are located underwater. It is true that at present we do not know most about the underwater cultural heritage located on the Galician coast.

Only a few shipwrecks have been found so far from the total number that we know sunk here, so the known ones undoubtedly are much less than those that occurred.[1]

3.4 Galeón San Girolamo (*San Jerónimo*) 1596

Toponymy is a magnificent tool when it comes to identifying and locating archaeological sites, both on land and in the sea. Names attached to geographic locations rarely have an arbitrary origin. In Corcubión Bay, close to Cape Finisterre, the place named in Galician language Punta do Diñeiro (money point) has been preserved. The archaeological excavation of a wreck in its vicinity explained the name with the recovery of many silver coins, transported by the *San Girolamo*,[2] galleon *Capitana* or flagship of Martín de Padilla's Armada, which lost around 25 ships to a storm on October 28, 1596 (Martín Bueno 1989a). This ship, also known as *San Jerónimo* or *Capitana de Ivella*, was one of the main ships of the 1596 Armada. about 460,000 cruzados coins were embarked in metal coffers in Lisbon, one of them lost in the wreck.

In the 90s of the sixteenth century "the ragusans Pedro de Ivella and Doliste speak highly of the ships" that they intend to contract with Felipe II, saying that their "perfection has been hastened by the measures of English and Biscayan galleons, and Ragusans, all of them taking the quintessence" (Casado Soto 1988).

One of the ships thus praised was the galleon *San Jerónimo* or *San Girolamo*, of about 1000 tons, *Capitana* or flagship of which was known as Illyrian squadron (Torres Falcao da Fonseca 2005), due to the origin of its shipowners.[3] The galleon was built in the Naples shipyard by the master Pedro Veneciano.[4] This squad was first under the command of Pedro de Ivella, and then that of his nephew Stephano de Olisti Tasovich, after the death of his uncle in Lisbon, in September 1596 (Torres Falcao da Fonseca 2005).

Pedro de Zubiaur was in Lisbon, in 1595, in charge of inspecting the capacity of the ships of this squadron, and in his report ponders their qualities: "The said three galleons (*Santiago de Galicia*,[5] *San Miguel* of Miguel Brauo, and *San Gerónimo*) are declared (…) to be of good fabric, new and strong, and fit to sail in Armada, for being ships level and strong, of good timber, and it seems that they will be good seagoing ships, capable of making sail against the wind, and that his Majesty may use them even if he is buying them" (Torres Falcao da Fonseca 2005).

[1] Around 238 wrecks occurred in Galicia between the sixteenth and the eighteenth centuries, of which 20 have been identified.

[2] *San Jerónimo*, as it appears in Spanish and in most historical documents.

[3] The owners were Pedro and his brother Estefano de Oliste de Ivella.

[4] "*Cabo maestro regio*", sic in original document.

[5] Wrecked in Ribadeo in 1597.

The same report describes the ship and the work necessary to dedicate it to armed tasks: "Galeon *San Hieronimo* (*Jerónimo*), captain of the said squadron, which […] captain Pedro de Urbino[6] gauged, was made in Naples, has a size of one thousand one hundred and eighty-five tons, and it is a galleon with no dead works. It needs yards, which have been made, and they were declared to be new and of very good construction and fit for Armadas without further work."[7]

A new Armada, destined to counterattack the English after their raid on Cádiz that same year, left Lisbon in October 1596 for Ferrol, where it should join other units under the command of Martín de Padilla, and then sail to Ireland to disembark an expeditionary force and open a war front to the English monarchy on Irish soil. The commander of the *San Girolamo* was Gregorio de Chinchilla. On the night of October 28, the Armada sailed off the Galician Coast of Death, ungrouped, in low visibility. The darkness was absolute at sea at a time when there was no illumination on the shore. That night, in the darkness, from the galleon they discovered blurred indistinct shapes that seemed to move "amid the scrambled spray" (Delgado-Iribarren 1956).

Chinchilla thought that these were galleys that ran the storm in their vicinity. On board, however, some did perceive that these were rocks and that it was convenient to separate from the coast going further west. These were probably some of the many shoals between Corrubedo and Finisterre. The position of the ships was much more to the east than the commanders, Chinchilla included, supposed, hence he did not admit to being in the vicinity of the coast and assumed that the rocks were other ships.

The prevailing opinion was that of the commander and three hours later, and no initiative was taken to amend the course towards the open sea, or to drop anchor and try to stop the march. Surprisingly for those on board, the galleon was wrecked against the coast. Although the ship was in a stable position, with a slight list to the side, soon it began to fall apart with the force of the waves, which took the lives of many of those who jumped into the sea. "Although it was a galleon strong like a castle, full of portholes, it fell apart like glass, and the storm and the waves of the sea that entered in it were so fearsome that they snatched many from the ship's deck; therefore, the priests gathered at the stern with almost all the knights. There they raised the crucifix as a sign of combat against the wrath of the sea and encouraged the knights to trust heaven. A huge hit, however, lifted the ship and opened an irreparable waterway. The end was fast approaching. But that blow was also a stroke of luck because upon its impulse the mainmast leaned and touched its upper tip on the ground, making an improvised bridge that reached the coast. Most of the survivors that made up the ship's crew crossed there. Some who had perched on the

[6] Probably Pedro de Ivella.

[7] "Relación delas medidas que tuvieron los doze galeones levantiscos de la esquadra del general Pedro de Ybella, conforme al arqueamiento que se hizo en la ciudad de Lixboa por el general Antonio de Vrquiola, en presencia del veedor general don Alonso de Velasco y el contador Pedro de Ygueldo", AGS, Guerra Antigua (GA), Legajo 513–204. Bernabé de Pedroso y Francisco de Bárzena, La Coruña, 12 de marzo de 1598.

rigging found themselves safe without much effort. Violently hit by the same waves that had formed it, however, this bridge was reduced to splinters with pieces of rope and canvas" (Delgado-Iribarren 1956).

The stern broke as a result of the waves. The bow crashed against the cliff, as was demonstrated during the 1987 archaeological intervention. The rapid destruction of the ship was evident during the campaign led by Professor Martín Bueno, just as the hull was lying on the port side, which undoubtedly favored the rescue of the people when the main mast collapsed on that side (Martín Bueno 1989a, b).

This galleon was the one carrying the biggest number of troops and crew of all those that sunk on the day of San Simón and San Judas: 406 soldiers and 118 sailors, of whom 384 were saved and 140 perished. Among the deceased were two Jesuit priests on the way to join the Navy, along with thirteen others, by order of the General of the Jesuits, Claudio Aquaviva. Captain Chinchilla survived and came ashore holding a log.

Years after the loss of this galleon, one of its shipowners, Stephano de Oliste, complained: on June 13, 1598, he wrote to the King from La Coruña, listing the jobs in which he and his family had served the Crown: "[…] Because I did not file the accounts of what was left to me from the galleon *San Hieronimo* (*San Jerónimo*), which was lost in the service of your Majesty, I am so poor that for my sustenance I have only the salary that your Majesty commands me to be general of a squadron, and this one paid me so badly that it forced me to beg to your Majesty" (Torres Falcao da Fonseca 2005).

3.5 Salvage and Archaeological Interventions

The shallow depth of the shipwreck site allowed the rescue of most of the supplies, artillery and, most importantly, the money to pay the troops. Francisco de Moscoso, in a letter to King Felipe II, dated in Ferrol on October 30, 1596, informs him that the one he called *Capitana de Levante* (*San Jerónimo*), carried "a box with thirty-six million escudos of your Majesty's money." The recovery of this cash was carried out by divers who located the coffers (Torres Falcao da Fonseca 2005), except for one of them which, when broken, had scattered its contents. The first diver who descended to the wreck in freediving "by evidence took out 2 handfuls of *reales*." The importance of the money lost was so great that the Governor of Galicia ordered the construction of some dredges with which to recover the coins buried in the sand, although with little hope: "some dredges to get the money out of the sand but if there is a lot of sand over, nothing will be enough."

The most of gunnery was also rescued, however at the end of May 1986, two divers[8] discovered a stone thrower cannon (*pedrero*). This find would give rise to the first underwater archaeological intervention carried out on the coasts of Galicia. The

[8] José Trillo López and Jesús Mendoza Martínez.

piece was recovered by the Spanish Navy in 1986 and is currently kept at the Ferrol Naval Museum. After the discovery of the gun and given its importance, the Spanish Navy prepared an underwater intervention ship—ESPS *Poseidón*—from Cartagena, which was later relieved by another ship that continued with the removal of materials from the wreck. Military divers recovered numerous objects, including a huge amount of silver coins. Several timbers were also removed from the site which, according to what is found in the Galician Federation of Underwater Activities Archive, for the most part fell apart "upon reaching the surface. Those that were raised in one piece were frequently hosed."

The Galician Federation of Underwater Activities, through its Department of Underwater Archaeology, advised the Corcubión City Council, on whose shores the wreck was located. An agreement between the Spanish Ministry of Defense, the autonomic government of Galicia and the University of Zaragoza, allowed the beginning of a scientific project, called *Finisterrae 1987*, which started in July of that year and was directed by professor Manuel Martín Bueno, from the Universidad de Zaragoza, and authorized by *Consellería de Cultura, Xunta de Galicia*. The intervention was included in the survey project of the Spanish coast and was also included in the European Project *Forma Maris Antiquis* that had the purpose of preparing an Underwater Archaeological Chart of the European Coastline.

During the excavation, the site was divided into four different areas. The first of these was established under a grid of 4 meters on each side, located on a sandy bottom, at the foot of the cliff where it was supposed that structural elements and heavy materials of the wreck could be deposited. At this point there was a layer of sand with loose remains under which the concretions formed by metal and stone were located. This accumulation was removed by means of a suction pump and mechanical means, and the concretions were found to be made up of iron artillery shells, lead ammunition of small arms and coins. Under it, a piece of wood was documented (Martín Bueno 1989b).

The northern end of the grid offered remains of wood in a relatively good state of preservation, with no signs of damage by xylophagous organisms, or alteration due to contamination of metallic elements. These timbers, however, were fragmented by marine dynamics. The grid facilitated the discovery of some silver coins that were interpreted as coming from the area closest to the cliff. These pieces were quite affected and showed a very compact crust that had made almost all the nodular metal disappear. The coins first recovered, had the shield of King Felipe II. In the excavation, no defined structure of the ship was identified, attributing the fact that the wreck had been destroyed (Martín Bueno 1989b).

Zone 2 was located between the grid where the excavation was carried out and the coast, in a "deep crack in which the movement of the water was depositing a series of materials, especially numismatics" (Martín Bueno 1989b). It was in a narrow gorge located in the submerged part of the coastal cliff. This area was about 4 m deep and sometimes was reduced to 30 cm wide. It stored important sets of coins and lead ammunition, cemented to the bottom between the cracks. Its removal had to be done by hammer and chisel and in blocks, to avoid affecting the pieces individually. The third area was in a rocky massif with anfractuosity in which metallic remains were collected, concreted to the rock. A fourth area was located at the foot of this massif, where elements from the bow of the ship were located. Finally, a last zone defined as a littered area, theoretically located aft and outside the grid.

A ring with the anagram of the Society of Jesus was recovered in the archaeological intervention of the University of Zaragoza. This personal object undoubtedly belonging to one of the two Jesuit priests drowned in the shipwreck, the only jesuitic priests who perished that fateful night on the Armada. A very similar object was recovered from the *Girona* shipwreck, a galeass sunk at Lacada Point, Northern Ireland, on November 26, 1588 (Martin and Parker 1988; Glover 2008), which shows the interest of that religious order in the spiritual reconquest of the Kingdom of England (Fig. 3.1).

The area surrounding the shipwreck was a clean sandy bottom that moved with the marine dynamics. In the archaeological intervention 3302 silver and two gold coins[9] were recovered, which must be combined with those previously recovered by the Navy and even earlier, in the moments after the shipwreck. In addition to those recovered—around 50—on the coast by a person using a metal detector. To all these must be added those coins looted by other people. The presence of so many coins is explained by the box that broke in the shipwreck, on October 28, 1596. The coins were transported in coffers, probably in leather or textile sacks. As mentioned above, much of the payload was recovered immediately after the wreck, but a single one of these boxes was broken, scattering its contents.

The monetary collection has great temporal variability, with mintings from Segovia, minted a few months before the shipwreck, to mintings from the Spanish Catholic Monarchs (late fifteenth century to early sixteenth century). As for their

Fig. 3.1 Jesuit ring recovered on San Girolamo's wreck. Corcubión

[9] They are kept in San Antón Museum, La Coruña.

origin, a considerable amount of good quality coins comes from Portuguese mints of the reigns of kings Manuel I and João I.

Among the coins of the Catholic Monarchs there are pieces of 1, 2, and 8 *reales*. Those dedicated to Juana and Carlos follow, these being the first mintings made in America. These pieces are known as *columnarios* in which the columns of Hercules appear together with the legend *Plus Ultra* (Martín Bueno 1989b).

The most important set of coins is the one made up of the pieces minted during the reign of King Felipe II, of which the most abundant were those issued after 1556. In this year, the monetary scheme based on the real of eight of 272 *maravedíes* was established, with dividers four, two, one, and a half real. Many specimens from the American mints have irregularities due to cuts to adjust them to the weight, and many lack date on the inscriptions that facilitate their identification. The variability of origin and chronology of the coins from this shipwreck led Professor Martín Bueno to point it out as a symptom of the economic hardship of the reign of King Felipe II, where the shortage of cash led him to "extract the most hidden resources" (Martín Bueno 1989a). The study of the coins recovered during the archaeological intervention of the year 1987 is complete with mints, testers, dates, etc., awaiting publication. During the archaeological intervention, numerous lead projectiles from light weapons were also recovered, as well as artillery stone shots.

The work carried out during the years 1986 and 1987 by the Spanish Navy and the University of Zaragoza coincided with a partial removal of the layer of sand that usually covers the bottom. In recent years, thru the ForSEAdiscovery and other projects, we dived frequently in the Cape Finisterre area.[10] In those moments when the situation of the sediment that covers and protects the wreck has been monitored, virtually nothing from the area in 1987 was found to be visible out sand (Fig. 3.2).

Regarding the artillery, only the bronze stone thrower (*pedrero*), recovered by the Navy in 1986 was found. The other armament, a total of 28 pieces, as mentioned in a letter from Stephano de Oliste to the king, is only partially accounted for. Eighteen guns were salvaged immediately after the shipwreck, but nine remain unaccounted for. As already mentioned, the only gun was recovered in 1986 and it is a stone thrower (*pedrero*) cast in Naples by a member of the Iordani (or Giordani) family, possibly Cristóforo or Giovanni Battista. The breech clearly reveals the founder, with a prominent cascabel with the typical button of this origin (Ridella, San Claudio and Casabán 2017), and the touchhole is surrounded by a square. The Iordani family worked in Naples between the years 1583 and 1675. Based on similar preserved pieces, we believe that it may have been cast between the years 1583 and 1603 (López Martín 2015) (Table 3.1).

The handles are heavily corroded, so it is not possible to discern their motifs. It has been suggested that they represent each two dolphins joined by their tails (Ridella et al. 2017).

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[10] Proyecto Finisterre; ForSEAdiscovery Project PITN-GA 2013–607,545; Galician Shipwrecks: http://www.galicianshipwrecks.com/.

Fig. 3.2 The rear part of the *pedrero* found on the wreck of the galleon *San Girolamo* or *San Jerónimo*. The shields and marks are eroded. This piece was cast in Naples by a member of Giordani family

Table 3.1 *San Girolamo*, Pedrero cannon measurements

PEDRERO SAN GIROLAMO	mm
Total length	2500
Conventional length	2180
Camera length	1465 (still loaded)
Trunnion diameter (min/max)	91.5/88.5
Bore	177
Trunnion Length (máx)	83.5
Diameter at the touchhole	338

The study of the cannon crest is not possible due to its deterioration. It seems to correspond to that of some high member of the nobility, presenting the shield crowned by a helmet topped with a sword (?) and flanked by a horse or dragon to the left and an anthropomorphic figure armed to its right. It seems to have vestiges of a necklace or *phylacterium* surrounding the shield. Other guns preserved from the same founders carry the patrimonial shield of King Felipe II, with the crests of the Monarchy states, surrounded by the collar of the golden fleece, and crowned by three helms, in turn topped by two dragons flanking a tower defended by a knight with a sword (López Martín 2015). In the upper band of the breech there are traces of the weight, measured for Neapolitan use in *cantara* and *rotoli*. This gun was loaded with a stone ball, visible through the bore. In addition to the previous piece, divers from the Navy recovered a breech load server, probably from one of the four *esmeriles* known to have been on board the galleon.

With respect to artillery ammunition, in 1987 several limestone stone shots (*bolardos*) were recovered from the wreck. Those projectiles, kept in the Museum of the Castle of San Antón, La Coruña, correspond to two different calibers, in line with the presence of heavy and light stone throwers, as detailed in the documentation (Ridella et al. 2017). Other projectiles were previously removed by the Spanish Navy (Table 3.2).

For the solid iron ammunition, its state prevents us from clearly establishing their calibers. A set of these pieces was documented, concreted together, preserving the shape of the wooden container where they were deposited. Its dimensions were approximately 2 × 2 m. The position of the ammunition inside the ship was estimated between the center, and toward the bow. The accumulation of ammunition led the excavators to argue that the ship was heavily armed (Martín Bueno 1989b). However, nothing is said about the existence of individual weapons.

At a distance of 30 meters northeast of the grid, part of an anchor shank was located. It kept one of the arms with its fluke and a fragment of ring. Its length was over 2 meters, and it appeared to be made of wrought iron. That this piece is integrated into the wreck suggests that the ship did not anchor before hitting the coast, confirming the story of the shipwreck (Delgado-Iribarren 1956).

The archaeological items from the site that was once the *San Girolamo* galleon, "Ivella's flagship" are currently on display in two Museums, one in La Coruña, and the second one in Ferrol. The intervention from Universidad de Zaragoza, in addition to the recovery of materials made by Spanish Navy in 1986—and the

Table 3.2 *San Girolamo's* ordnance (Ridella et al. 2017)

Type	Provenance	Weight marked[a]	Weight (kg)	Shot
Demi cannon	Naples	C^A 22 - R° 5	1965	Iron: 12 libras;
Saker	Genoa	C^A 21 - R° 41	1020	Iron: 8 libras;
Saker	Genoa	C^A 22 - R° 6	1051	Iron: 8 libras;
Saker	Genoa	C^A 21 - R° 27	1013	Iron: 8 libras;
Sacre	Genoa	C^A 21 - R° 41	1020	Iron: 8 libras;
Falcon	Naples	C^A 7 - R° 25	646	Iron: 5 libras;
Falcon	Naples	C^A 7 - R° 10	633	Iron: 5 libras;
Pedrero	Genoa	C^A 19 - R° 1	906	Stoneshot: 12 libras;
Pedrero	Genoa	C^A 18 - R° 87	899	Stoneshot: 12 libras;
Pedrero	Genoa	C^A 17 - R° 14	817	Stoneshot: 12 libras;
Pedrero	Naples	C^A 11 - R° 50	1025	Stoneshot: 12 libras;
Pedrero	Naples	C^A 11 - R° 50	1025	Stoneshot: 12 libras
Pedrero	Genoa	C^A 19 - R° 48	928	Stoneshot: 12 libras;
Pedrero (light)	Naples	C^A 3 - R° 40	303	Stoneshot: 4 libras;
2 Esmeriles	Naples	C^A 3	243	Stoneshot
2 Esmeriles	Naples	R° 40	35	Lead

[a]C^A: Cantara - Neapolitan 89,1 kg. Genoese Cantara- 47,649. R°: Rotulo – 91gr

conservation treatments—involved the writing and dissemination of several scientific articles (Martín Bueno 1989a, b). Furthermore, an exhibition was inaugurated at La Coruña in 1989. Despite the recovered materials and all those that could have been later removed due to looting, we believe that the site can still house many items of interest. Information from local fishermen that, sometimes, after storms, report large amounts of wood visible, leads us to consider the possibility that this wreck still contains a lot of valuable information about the historical process of its origin.

The loss of 25 vessels from the 1596 Armada on the coast of Finisterre, on the night of October 28, 1596, did not stop the offensive plans of the Spanish monarchy. After the summer of 1597, a new Armada left Ferrol to the English mainland. The target was Cornwall, the closest English territory to the Iberian Peninsula. Once again, the atmospheric conditions prevented the landing of troops, because despite almost all ships having reached the planned disembarking place, the fleet was driven south by the same winds that so effectively supported the English incursions on the Spanish coasts.

3.6 Galleon *San Giacomo di Galizia*

After the withdrawal of the 1597 Armada, the vessels returned to the Iberian Peninsula in a somewhat scattered way, driven by the same winds that prevented them from reaching the Cornish coast. The northward progression once again proved to be much more eventful than the southbound courses in the Gulf of Biscay. The ships quickly and safely reached ports in the Spanish north. One of those ships was the *Almiranta*[11] of the Armada, the Ragusan galleon *San Giacomo di Galizia*, which, disconnected from the bulk of the force, had to break through to Spain fighting against four enemy navy ships. Ambrosio de Castro, who was on board the galleon, said "that he fought at the same time with three Flemish and one Englishman, and that the Flemish brought musketeers, which according to him were from the enemy Navy."[12] After the ravages caused by the storm and the combat, the ship sailed to Ribadeo in early November 1597. By then there was widespread concern for its destination and the 91,000 ducats it was carrying "after the rigor of the storm had passed, I hope in God that this in safety."[13]

The first news from the galleon arrival were offered by Don Alonso de Velasco, on November 6, 1597, in a letter sent to the king (Council of War) in which he reports that: "The galleon *Santiago* has entered Ribadeo in bad shape and with many sick but blessed be the god who has delivered him and the ninety-one thousand *ducados*." Barnabas de Pedroso reports, on November 6, 1597: "The Galleon *Santiago de Galizia* with two other *hurcas* have arrived in Rribadeo, the Galleon is

[11] Second in command in a squadron or fleet.

[12] AGS, Guerra y Marina, Legajo 491, document 139.

[13] AGS, Guerra y Marina, Legajo 491, document 136.

so destroyed that it can be had by a miracle, the people are severely injured and sick from the hard work that they have suffered, and there is order and errand for them to be remediated."[14]

To guide the galleon into port it was necessary to light fires on the coast and give support from land, as expressed by King Felipe II himself: "and through God and the fires that were made in the highest mountains entered the port of Ribadeo four ships and among them the galleon *Santiago de Galiçia*." The galleon and its crew arrived in poor condition. The town came to aid the crews of the ships, receiving for this the gratitude of the *Adelantado* Martín de Padilla, by means of a letter dated November 16, 1597: "The service that this town has done to His Majesty in the help that he has given to escape the Galleon *Santiago*, has been very proper, of the natives and peasants of it, and of the Government that they have, and much more of Mr. Cuyares, to His Majesty I have given account of it, so that he esteems it as it is reasonable, and I for my part am very desirous of which is offered that I show as grateful as I am of that care." After showing his appreciation, he asks the villa for accommodation for people: "Still, for some day in the interim order is given to pay the people who go with great diligence, it will be necessary to house in that town the two companies that came in the said Galleon and the soldiers of the other *nauios* who, as I say It must be for a few days."[15]

This ship was described by contemporaries as magnificent. It was built at Castellammare de Stabia, Naples. Its captain and owner was Giovanni di Polo and its builder was the Neapolitan shipwright master Colela Bonifacio. *San Giacomo* was one of the 12 great galleons of the Illyrian squadron of Pedro de Ivella. After their first exit to the ocean, these units, earned the favor of King Felipe II: "well they give to understand the galleons with which you serve me, the care and courage of who governs them" (Gelcich 1890). Not only were they well built, but special care had been taken in collecting the timber necessary for their construction: "The wood of these galleons is from the forests of Naples, Mount Gargano and Albania, from mountain ranges facing the sun of real oak cut with a waning moon in December, January and February." The ship's structure was entirely made of oak (Domínguez Delmás and García González 2015), totally covered with pitch for conservation. The source of the wood used in the construction of this ship, was established in southern Italy from the work carried out by ForSEAdiscovery team.

The good reputation that this ship gathered among all those in the Armada meant that, along with the galleon *San Bartolomé*, both were in charge of transporting 120,000 ducats "who, being the best and strongest, got into them." The galleon *Santiago de Galicia* received 91,000 escudos of this amount "with being the strongest and best in the squadron." Its dimensions were 44.5 *codos* of keel; 61 *codos* on the second deck, 60 *codos* in length; 20.5 *codos* of beam; 13.5 *codos* of depth in hold; 7.25 *codos* on the flat of the floor timber; 7.25 *codos* high on the runs (*raser* or *rasel*) that continues to the middle of the galleon; 2 *codos* high on the entries

[14] AGS, Guerra y Marina, Legajo 491, document190.

[15] AGS, Guerra y Marina, Legajo 491, document 146.

(bow *raser*) and 1090 tons “a little more or less” of tonnage.[16] Applying the 2/3 *codo* of Burgos rod, used in Andalusia and equivalent to 0.557270 m (Dueñas Fontán 2015), it offers us similar measurements to those documented on the wreck. Thus, the length assumed for this ship: 60 cubits in length, about 33,432 m correspond almost exactly to the 32–34 m documented on the wreck. The same occurs with the estimated beam of about 11.42 m according to the document transcribed by Fernández Navarrete (Table 3.3).

On September 28, 1595, in Lisbon, the ship was gauged at 1349 tons and crewed with 138 seamen. In the “Relation of the ships that were in the Armada of His Majesty and the tons that they have and the supplies that each one carried” only 1200 tons are attributed to *San Giacomo*. At the same time, 16 bronze guns of Genoese cast, property of the shipowner were reported, although in the document produced in June 1595, in Cartagena, the total given was 28 pieces, 12 of which were probably Royal property (Fig. 3.3).

3.7 The Shipwreck

Upon arrival in Ribadeo, *San Giacomo di Galizia* was by no means safe. On November 13, 1597, the deputy mayor of the town of Ribadeo, together with two councilmen of the town, met to establish the necessary measures for the correct supply of bread to the town, needed for the many infantry and horses as well as the crews of the two *urcas* and the galleon “... and see the dho galleon through...” The shipwreck occurred on a date between the day of its arrival, November 6, and

Table 3.3 Shipowner *San Giacomo’s* gunnery

	Type	Shot weight (pounds)	Weight
1	Demi cannon	20	Genoa 42 C^{A}, 58 rótulos
1	Demi cannon	20	42 C^{A}, dos rótulos
1	Saker	8	Naples 13 C^{A}, 90 rótulos
1	Saker	8	Naples 13 C^{A}, 90 rótulos
1	Demi saker	4	Genoa 14 C^{A}, 22 rótulos
1	Demi saker	4	Genoa 14 C^{A}, 22 rótulos
1	Pedrero	8	“No weight number”
1	Pedrero	8	“No weight number”
1	Pedrero		Genoa 7 C^{A}, 68 rótulos
1	Pedrero		Genoa 7 C^{A}, 68 rótulos
1	Pedrero	14	Genoa 9 C^{A} y 79 rótulos
1	Pedrero	14	9 C^{A} y 90 rótulos
4	Esmeriles	2	Naples 40 rótulos

[16] “Relación de la Fábrica de doze galeones de guerra de la escuadra Yllirica de Pedro de Ivella”, s.f. Museo Naval de Madrid (MNM), Colección Navarrete, Tomo IX, doc. 27.

Fig. 3.3 Photogrammetry of the Ribadeo's galleon site. We can see the wreck, during 2019 excavation season with the bow to the right bearing North. The upper frames in fact are beams from the first deck. Really frames are seeing on the low right of the picture. The excavated central area is surrounded by bulkheads. The white scale is 30 m

November 13, 1597, and forced "the people to jump ashore." The rescue of people is not mentioned for the two *urcas* that lied next to the *Santiago de Galicia*, so we must understand that they did not sink at this time, in the estuary.

As for the causes of the wreck, its owner, Giacomo di Polo, explains "... because of the bad command of the leaders..." (Casabán Banaclocha 2015). This Ragusan shipowner estimated the losses of his ship at 40,000 ducats.[17]

The wreck site experiences strong tidal currents, something that must have favored the wreck to fill up with sand very quickly. That would explain both the difficulty of its salvage and its good preservation. To our knowledge there was no loss of human life. The crew was saved, as the cavalry and, of course, the 91,000 ducats it carried. The ship was lost during the incoming tide, as shown by the bow, which points to the river mouth. In a place with tides greater than 3 meters, undoubtedly a part of the wreck remained above the water. The absence of guns on the shipwreck shows that they were rescued, probably immediately after the shipwreck. The wreck, apparently, keeps its structure up to the water line in the most of it, buried in the sand, and may even go beyond at some points.

3.8 After the Wreck

The rescue work began immediately after the wreck, focused on everything that could be used. The shallow depth at that point allowed the rescue of the artillery, most of the rigging, and other ship parts and cargo. The salvaged parts must have been substantial because on February 7, 1598, Giacomo Giovanni di Polo asked the king's authorization to manufacture another galleon with the parts salvaged, "according to the layout and measures of those of Biscay, because it is more on

[17] AGS, Guerra Antigua, Legajo 530–59.

purpose to serve Your Majesty's Armada." For this, he also requested a Royal *Cedula* that would allow him to obtain the necessary wood "so that he can take all the types of wood that the factory would need in the Reyno de Galiçia and Principality of Asturias" (Torres Falcao da Fonseca 2005).

The stranded ship soon started to lose its emerging parts, due to the dismantling for the recovery of objects and structures, as well as the mechanical action of the current, compounded with biological attacks. The lower part of the ship, however, remained buried until the dredging carried out in the estuary exposed it.

3.9 Archaeological Investigation

In 2011 the Galician Port Authority carried out dredging in the Ribadeo estuary to facilitate the navigation to the Mirasol commercial dock. This channel had been the subject of dredging in the last decades and it will surely need new dredging works in the future to control the accumulation of sediment. The Autonomic Heritage Service of Galicia established an archaeological assessment of the dredging, in addition to an intensive survey of the area.

The first phase started by carrying out an intensive archaeological survey using divers, which did not offer any results. Neither did the sonar made prior to the dredging. This record, carried out with a multibeam sonar, revealed a sand bottom without any interesting element over the bottom surface. On November 14, 2011, the dredging operations began, and on November 28, work was stopped due to an obstruction in the intake filter. At the same time, the dredge captain reported having touched something hard. When the suction arm was removed, several stone fragments not matching the local geology, fragments of lead sheathing, and a fragment of a timber plank that was undoubtedly ancient in appearance, were discovered in the filter. These elements clearly showed the group show that they were the ballast stones of a lead-sheathed wooden ship. This could only mean that we were facing an archaeologically relevant wreck and an order was given to interrupt work at that specific point. The decision to interrupt the work was confirmed by the managers of the dredging and the construction management. In the early morning, the next day, after a first dive on the site, the existence of a huge wreck of high interest was confirmed.

On this first dive the profile of the ship was recognizable in all its length, except for a section of the port side, which remained buried. A massive quantity of the ship's structure was apparent, with no appreciable displacement of structural pieces. Specifically, frames, bulkheads, and planks were initially visible.

The wreck lied oriented along a north-south line, with the bow close to estuary mouth. It was preserved on its original layout and mostly in connection, with part of ship's frames protruding vertically, with hull planks still attached. The measurements suggested that we were close to the waterline, as confirmed by the presence of the lead sheathing that protected the hull, still attached, although in some places it was coming off due to the iron nail's corrosion. The preserved beam indicated that a substantial part of the hull was preserved in the sand, specifically the bilge. The confirmed presence of a deck at port side and several transverse bulkheads were arguments to confirm this hypothesis.

Amidships lied a tumulus formed by limestone ballast, identical to the one located by the arm of the dredger. Numerous stone and iron shots were visible among the ballast, along with metal concretions.

The ceramic shards located between the ballast were productions of Iberian origin, with a chronology around the sixteenth century. Most of these elements have a storage or transport functionality (*botijas*), table (bowl, plate, bottle, …) and toilet.

The forward portion was surveyed in 2012. Among other elements preserved there were the stem, the hull, a breast hook, and the beams supporting a partially preserved deck. Later, in the campaign carried out within the ForSEAdiscovery project in 2015, in addition to obtaining wood samples, a line of beams was documented, on the starboard side. Located below the first deck, at the ship's hold. It could be an orlop deck, which would reinforce the resistance of the ship's structure.

The deck clamps, intended to support the beams that in turn serve as a support for the deck, were observed documented on the starboard side, from practically amidships to the bow. They show a series of recesses to fit the transverse beams that would support a deck, as well as another one on the side, to fix them to the frames. The recesses on the shelves are located precisely at the gaps between frames, where the end of the beams would presumably be lodged. The deck clamps were attached to the frames by iron nails (Fig. 3.4).

The stem, located in 2012, when it was exposed due to some loss of sediment, shows that this part of the ship was upright on the bottom with a slight inclination

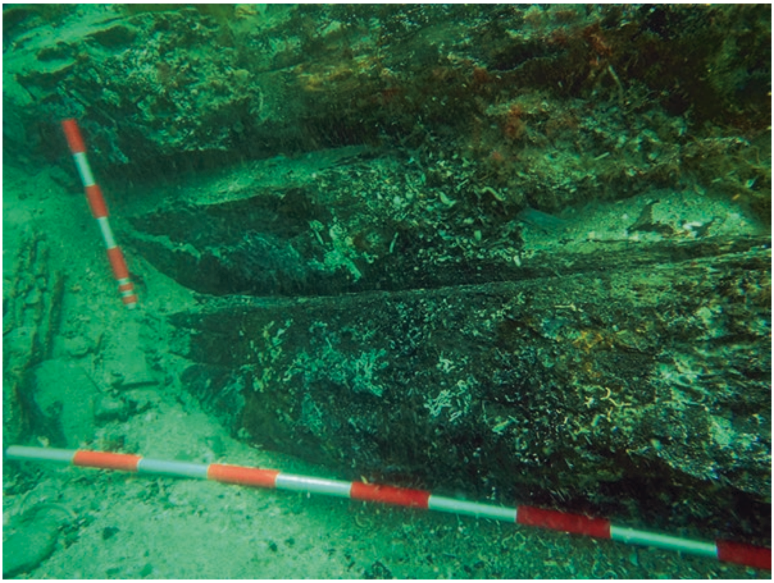

Fig. 3.4 Stern section of the wreck, on the right is the stem with the rabbet in the joint with apron

to port side. The exposed part was made of a single timber, with the lead sheathing that protect it still attached. A rabbet was carved on the stem was, to fit the hull planks' hoods. Toward stern and fixed to the stem there was an apron. We have not been able yet to document the union of the stem with the keel.

The conservation of decks is exceptional in shipwrecks from this timeframe. The first clue to the existence of a deck was a piece of timber on the ship's forward end, fitted over the apron and seated directly on a breast hook. This piece, in addition to reinforcing the bow, worked as a support for the deck while keeping the bow together. This end of the deck is made up of a single piece, notched to fit the apron, and a first fragmented transverse plank attached towards the stern. All timbers in this group are caulked and covered with pitch.

The waterproofing of this presumed first, or main deck, as it is the toughest on the ship (Fernández Duro 1867; Díaz and Martínez-Hidalgo y Terán 1957), guaranteed the buoyancy of the vessel, even if a waterway was opened due to a fire on it. This waterproofed deck is typical of sixteenth-century Spanish ships and is documented in the construction of galleys and galleons (O'Donnell y Duque de Estrada 2003), although this is the first case that we know documented empirically.

On the port side of the vessel we located a second and largest deck beam. It was preserved detached from the hull, out of the wreck, still attached to the frames and beams that supported it. Almost on the forepart on this deck remains a bulkhead. On the preserved deck portion, on the port bow, the distance between beams ranges from 28 to 33 cm, which means a highly reinforced structure, ideal for holding an artillery battery, as suggested by the presence of numerous stone shots on it. This deck spreads to the south and a gun carriage was discovered in the 2020 season, lying over it. That reinforces the presumption that we are in the main artillery of the deck immediately to the flotation line.

Along the starboard side, near the bow, some horizontal strakes seem to suggest that they were also part of a deck. This hypothetical remains would belong to a deck over the main one, located on the port side of the ship. On the starboard side, between amidships and the bow timbers closing the spaces between frames were surveyed. On the bow end of the shipwreck there are no gaps between the frames, as it is typical in wooden shipbuilding (Martínez-Hidalgo y Terán 1957). These frames are called *de reviro* or *reviradas* and are not perpendicular to the keel. We have not documented the presence of the apostles.[18]

The gap between frames appears above the main deck on the port side, where the heads of the futtocks appear between each two frames. This would suppose that below the main deck the frames are attached to each other, without gaps, as it appears in the bow and in the aft part of the starboard side. Along the starboard side, there are several fallen planks, separated from the hull but maintaining connection between them. As the iron fasteners connecting them to the frames corroded, they detached from the hull.

[18] Timbers parallel to the stem, although not born in the keel.

The ship is carvel-built, each strake placed above the lower one and fastened to the pre-erected structure (frames first). The hull structure is around 50 cm thick, 12–15 cm corresponding to the inner (where they exist) and outer planking, and the remaining 20–25 cm corresponding to the frame timbers' molded dimension. The ship is of strong construction as befits as fighting ship.

The hull planks are attached to the frames with iron nails. The careful shaping of the planks, their clean edges, as well as their thickness, show a high technical level of shipbuilding. The planks ends are joined by oblique scarps that end at a right angle to the edge of the planks. The nails are perceptible, thanks to the concretions they have formed. Among the shipbuilding elements surveyed, there are several bulkheads. The first ones were located near the ballast pile on the first dive, perpendicular to the longitudinal axis of the wreck. Other bulkheads were located later, always in the forward half of the ship. They are made up of oak planks, held in place by vertical shores with no nails, which were probably fixed to the beams. The whole set is still in connection on original position. These bulkheads are located below the deck, probably over the bilge, and apparently linked to the beams, perhaps only to the orlop. The bulkheads divided the hold and were not a fixed part of the structure: they could easily be removed, depending on stowage needs. The edges of the strakes that make them up are grooved.

Over the displaced deck, on the port bow area, a bulkhead divided two different environments. The one located forward contained a set of varied calibers stone shots, along with *botija* shards. The after space contained a barrel and barrel staves. The ballast, located amidships, in a pile, seems to have been contained with transverse and longitudinal bulkheads separated about 3 m. The ballast was apparently contained between two bulkheads, perpendicular to the ship's longitudinal axis. More ballast has not yet appeared fore and aft of this cluster of ballast stones.

Several turned wooden balusters were located between the central ballast pile and the stern. These are very unusual elements since, being pieces of little weight and size, usually disappear in the site formation process. They are represented on pictorial works and preserved models and were used on stairs, lamps, and coamings, as well as in stern ornamentation. A pillar in chestnut was associated to balusters, suggesting that it was the axis of a staircase whose balusters would be arranged in a spiral around it.

The submerged hull was protected from marine organisms with lead sheets attached to the hull. Its use is known in Spanish ships from the beginning of the sixteenth century. It was widely justified in the Caribbean because the ease with which xylophagous attacks wooden hulls.

The existence of lead sheathing has been documented on the *La Juliana* shipwreck (Site 1), belonging to the 1588 Armada, in Streedagh, Ireland. This merchantman, built in Barcelona, was integrated into the Levante Squadron of the 1588 Armada (Birch and McElvogue 1999). The sheaths are barely one-millimeter-thick, attached directly over the hull planks with no padding between. The nails that fixed it, now disappeared, were made of iron and had a square section, according to the traces left on the plates.

One of the wreck's most striking elements is the central ballast pile. Ballast is essential to stability of a ship by lowering the ship's center of gravity. In *San Giacomo* it was made up of a large amount of gravel and medium-sized stones, identified as sandstones, limestone, quartzites, and volcanic stones. The nature of stones and pebbles denoted that the ship had been weighted at a different location than the one found.

Several large caliber stone shots located among the pile were also identified as ballast. These are projectiles with a caliber greater than 300 mm and could not belong to the ship's ordnance, unless it was part of the army's impedimenta to be landed in Cornwall, it was shipped due its weight to contribute to the ship's stability. Anyway, its location among the ballast, suggests that such heavy elements had to be transported as low as possible to contribute to the balance of forces that make a ship stable on the sea. Lead sheathing, perhaps weighing several tons, helped lower the vessel's center of gravity.

Rope was a fundamental element for navigation in the period prior to mechanical propulsion. Most of the activities on board a ship involved in one way or another the use of ropes for various types of rigging. Examples from this historical period and from this cultural context have been preserved in very few archaeological contexts. Some rope elements were surveyed south of the ballast pile. Their gauge is around 40 or 50 mm, so they were probably used as running rigging. Some partially buried fragments showed a larger diameter.

Artifacts have not been raised for lack of conservation budget, unless they were endangered. In addition to the ceramic containers, remains of casks were also found.

Other organic containers, rarely preserved in most archaeological contexts, were preserved on this one, including some type of basketry not fully defined at the moment.

We have documented ceramic pieces belonging to the kitchen, table, storage, and transport uses, in addition to personal hygiene. The presence of a stoneware ceramic fragment stands out, probably of German origin and sometimes used to contain liquors. Ceramics of Andalusian and Portuguese origin abound with green and molasses glazes, with reddish and dark pastes, generally refined or very refined, except in the case of vessels intended for transport or storage, as is the case of the *botijas*. Several fragments of a blown glass goblet were recovered from the stern area, correspond to the social category of the people housed in this part of the ship.

Regarding the artillery, no pieces were found yet, although some auxiliary elements were observed. Several metallic concretions are present, formed from artillery elements, mainly iron projectiles. In the middle of the wreck, near the center line, a tapered iron object, which could correspond to a small cannon, is enclosed in a concretion. The absence of artillery pieces on the wreck is probably a consequence of having been recovered in the past. The wreck is −4.6 m deep, so at the time of the wreck much of the upper works must have remained above the water. This situation lasted for a relatively long period of time in a place sheltered from the waves, helping the recovery of most valuable objects, among which were the guns, especially the bronze ones (Fig. 3.5).

Fig. 3.5 Two of three "*alcuza*" servers found on the concretion located close to stern. They are bronze made for a specific gun

A large concretion of peculiar shape was located toward the stern of the ship, formed by a set of metal objects in which three *alcuza* servers for breech loaders stood out. Its peculiar disposition, almost vertical, probably was due to the dredging impact. According to the documentation, in *San Giacomo di Galizia* mounted two *esmeriles* owned by their shipowners (Torres Falcao da Fonseca 2005). The *alcuza* servers are common on ships of this chronology. In the 1588 Armada wreck at Streedagh, was discovered a similar server (Birch and McElvogue 1999), another one in San Girolamo wreck sunk in 1596 on Cape Cee - Punta do Diñeiro (San Claudio Santa Cruz 2018).

The test of inserting one of Ribadeo's servers into the chamber of an *esmeril* found on a Cape Finisterre shipwreck, showed that they could, in certain cases, be interchangeable, mostly when we consider that the artillery of *San Giacomo di Galizia* was also cast in Genoa. Two of the servers have similar characteristics (27 cm long and 15 kg in weight), which indicates that they should correspond to a specific piece, which also supports the dimensions of the molding that would be inserted into the bore of the piece. Compared to the third server, which is slightly smaller (24.5–25 cm long and 12 kg in weight), it has a slightly smaller diameter at the mouth than the other two pieces. The evident lack of standardization, each piece only works with its own servers, we can imagine the logistical complications involved. In all cases the servers are marked with a number engraved on their surface, on the touch hole. This hole is in all cases located to the left of the handle. The server handle would be supported against the right-side wall of the chamber.

Five different stone shots have been recorded, with diameters of 88, 117, 153, 224, and 321 mm. Iron shots are not easy to study, due the concretions that surround them. We suppose that at least some of them would have a diameter around 130 mm. The larger stone shots *bolaños* in Spanish (321 mm) were located in the ballast pile. As mentioned above, the larger caliber stone projectiles were probably transported as ballast and were not objects of primary use. In the artillery report, made in Lisbon, in 1595, the six Genoese bronze stone throwers *pedreros*, ship owners' property, were about 9 and 14 pounders, corresponding to calibers far away from these large stone shots.

It could, however, be that this ammunition was part of the army's impedimenta to be landed in Cornwall. If this was so, this caliber would be adjusted to a mortar bombardment, used on ground operations, in the siege of strongholds.

The absence of anchors indicates that they were recovered, due to their value. The ship could be at anchor when it sunk, and anchors can still be in the estuary, buried in the sediment. Perhaps this was the reason why Giacomo Giovanni de Polo stated that the galleon *San Giacomo di Galizia*, was shipwrecked due to the "bad command of the rulers was lost in the town of Ribadeo [...]" although blaming somebody is a common occurrence in these situations, and does not prove anything (Casabán Banaclocha 2015).

3.10 Conclusions

Aquatic environment allowed a fast and easy transport and favored the exchange and the relationships between human beings. War, which is nothing but another form of human interaction, was no stranger to this easy communication. The north of the Iberian Peninsula, so close to the enemies of the Hispanic crown in the last years of the sixteenth century and in the early seventeenth century was affected by a continuous state of war.

Few human activities do not leave material traces that archaeologists cannot find and study. War is not one of them, and in particular naval warfare has produced material remains that we are now able to study. The sites that this confrontation has left in Galician waters constitute the best accessible collection of naval remains from the end of the sixteenth century.

The shipwrecks presented in this paper are considered to be of Hispanic construction for all intents and purposes. Despite having been built in Naples, by Ragusan shipowners, these ships were planned and designed for the service of King Felipe II, both in the Atlantic and the Mediterranean. Their construction was excellent, and the timbers used carefully chosen. The advance in the study of these wrecks will allow us to advance the knowledge of Hispanic shipbuilding in Italy, comparing the Atlantic influence in the Mediterranean shipbuilding, and checking which of the traditions finally prevailed.

The wreck of the Spanish galleon *San Giacomo di Galizia* constitutes the archaeological site of one of the largest vessels so far located of its time. Not surprisingly, it is the *Almiranta*, second in command, of the Illyrian squadron, which constituted an important naval combat force on its time.

We are studying a Spanish ship, built specifically to be used in combat. Its construction is of high quality as shown in the careful carpentry and the thickness of its sides. This ship's qualities made it worthy of entering the frontline service of the naval forces of the greatest thalassocracy of its time. He was enthusiastically defined by Pedro de Zubiaur: "with being the strongest and best in the squadron."

The unfinished study of this site has already provided more information than that known so far on shipbuilding at the service of the Iberian monarchy at the end of the sixteenth century.During the ForSEAdiscovery project archaeological campaign of 2015, we asserted the potential of this site, and the good expectations about the quantity and quality of the preserved archaeological record. The wreck's situation is delicate; its long-term conservation being threatened in its current state. Since its discovery, the wreck has lost much of the sand that protected it. Its situation in the middle of a navigation channel worsens the situation due to the docking maneuvers of merchant ships. An accidental stranding would have disastrous consequences for the preservation of this unique example of sixteenth-century sailing. The periodic dredging of the canal, essential to its maintenance, and the operation of the dock is a Damocles sword hanging over the wreck integrity. Human action is a serious threat for the conservation of this site, although the natural factors that affect its conservation are not negligible.

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Chapter 4
Can We Identify the Ship Through a Multidisciplinary Approach? The Case of the Ribadeo 1 Wreck (c. 1597)

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Abstract During dredging works in the Ribadeo estuary (Northwest Spain) in 2011, a large and well-preserved shipwreck was discovered. Construction features suggested a date for the ship in the late sixteenth century, making this wreck a remarkable find for Spanish heritage, as it is one of the best-preserved shipwrecks from that time ever found in Spanish waters. Dendrochronological research on 32 samples retrieved in 2012 failed to produce dates for the timbers; hence the exact date of the ship and its possible construction area remained unknown. In 2015, additional archaeological survey works were planned on the site in order to document further exposed parts of the shipwreck, and to collect additional samples for dendrochronological research. Simultaneously, historical research was conducted in Spanish archives to search for documents referring to the wreckage of ships in the Ribadeo estuary in the sixteenth and early seventeenth century.

The results of this multidisciplinary research have led to the hypothesis that the shipwreck could be the *Santiago de Galicia* galleon, built in Castellamare di Stabia, near to Naples (Italy), in the late 1580s or early 1590s, and sunk in Ribadeo in 1597 CE. Dendrochronological dates obtained for two planks date the construction of the ship after 1580. Construction features of the shipwreck have been compared to those reported in sixteenth-century documents for the *Santiago de Galicia*

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galleon, and the potential limitations of our methods to identify the shipwreck, as well as the provision of timber in Naples in the context of dendrochronological findings are discussed.

1 Introduction

In 2011, dredging works in the Ribadeo estuary (Northwest Spain) led to the discovery of archaeological remains of an ancient wooden vessel (San Claudio Santa Cruz et al. 2013). The Ribadeo I shipwreck was found at 4.60 m of depth in a strong tidal area. After observing numerous wooden remains exposed by the dredging works, archaeologists discovered the structure of the hull preserved in its original shape. The shipwreck corresponded to a vessel with 32 m of length and 9.38 m of width, showing a length to width ratio of 3.41 (San Claudio Santa Cruz et al. 2013, p. 210). During the 2012 survey, a variety of archaeological evidence suggested that it was a warship, as its hull was covered in lead, the ship carried artillery and stone shot, and had caulked decks below the waterline, that would make the ship float even when shot below the floating line. The planking thickness of the outer hull and the scantlings of the beams and futtocks also indicated that the ship was a large war vessel. All these features lead to the hypothesis that the ship may have been a galleon. Samples were taken from different construction elements for tree-ring analyses, but this research failed then to provide absolute dates for the timbers. Therefore, the exact date of the ship, as well as the possible construction area remained unknown. However, structural and artifactual information retrieved from the remains of the ship (stone shots, ceramics and breech loaders) suggested a possible date for the ship in the late sixteenth or early seventeenth century.

In 2015, a new archaeological survey was carried out promoted by the ForSEAdiscovery project to further document the shipwreck and obtain additional dendrochronological samples for tree-ring analyses. At the same time, historical research was conducted in Spanish archives in search of information about sixteenth- and seventeenth-century shipwrecks in the Ribadeo estuary. The goal of this multidisciplinary approach combining history, maritime archaeology and dendrochronology was to attempt to identify the Ribadeo I shipwreck (Fig. 4.1).

2 The First Lead Toward the Identification of the Ship

In June 2015, the discovery at the Municipal Archive in Ribadeo (RMA) of a document dated November 13, 1597 provided the first clues about the possible identity of the shipwreck under study. According to the minutes of a meeting of the municipal council, “the Santiago galleon and two *urcas* from the royal navy” had arrived

Fig. 4.1 View of a deck and bulkheads still joined together between some stone shot and barrel remains

in the harbor of Ribadeo, badly damaged and loaded with infantry and horses.[1] The crew went to the village begging for food, so the municipal council resolved in this document to provide the infantry with bread. Two other documents in this archive, one from February 20, 1598[2] and another one from November 8, 1599[3] referred to the Santiago galleon as the "Santiago de Galicia" galleon, in relation to the good deed of the village of Ribadeo supplying the infantry with victuals.

During the research, significant advances were made in identifying three potential vessels that sunk in the estuary within a narrow range of 7 years (1597–1604). According to the historical data, the earliest vessel noted was the *Santiago de Galicia*, sunk in November 1597, a galleon built in Naples as part of the 12-galleon fleet of Pedro de Ivella and Estefano Dolisti.[4] The second vessel was an *urca* sunk in December 1597. It arrived with the galleon *San Francisco de Paula*, lost from the

[1] RMA, *Libros de Actas,* 6 (1595–1611), fs. 49

[2] RMA, *Libros de Actas*, 6 (1595–1611), fs. 56a-56r

[3] RMA, *Libros de Actas*, 6 (1595–1611), fs. 82r-84a

[4] RMA, *Libros de Actas*, 6 (1595–1611), fs. 49

fleet of Aranburu.[5] Finally, the third vessel was the caravel *Santiago*, lost in October 1604.[6]

3 Archaeological Construction Features of the Ribadeo Shipwreck

In 2015, new archaeological survey and documentation works revealed that the wreck was very well preserved from the main deck downward. The diagnostic timbers exposed were measured: first or second futtocks are 24 cm sided and 24 cm molded; the planking is 12–15 cm thick; and the main wale 15 cm sided. Inside the hull, all along the starboard side is a stringer attached to the frames with the same thickness as the planks, so that the hull planks, the frames, and the stringer are around 54 cm thick. There is no doubt that such thick planks provide a massive and solid structure for the hull and contribute to the robustness of the vessel. The planks seem to have been sawn tangentially, and they are pieces of great quality and good manufacture.

The most remarkable aspect in this site is the massive presence of construction timber, most of it in its original position. The hull is deeply buried in sediment, and the soft mud that filled the wreck immediately after the sinking contributed not only to preserve the structural timbers and archaeological artifacts, but also the original position of such elements in the ship's structure. Such conditions allow the hull to be vertical and show the stem as if the wreck were ready to sail away. On this stem, the rabbet carved to receive the hood ends of the hull planks is still visible.

One breast hook is still attached horizontally to the very extreme, inside the bow. Directly over this breast hook lie the forward pieces of a deck, still covered with pitch and with its components caulked, exactly as Alvaro de Bazán the older established that ships for the crown should be constructed, with a watertight deck below the flotation line (Fernández Duro 2007, p. 15). This deck finish, characteristic in Spanish ships of the sixteenth century, is documented in the construction of galleys and galleons (O'Donnell y Duque de Estrada 2003), although this is the first time that it has been empirically documented in a shipwreck. The forward part of the deck is carved to match around the apron, and the contact between them is also caulked.

Another remarkable characteristic is the presence of several transversal bulkheads. They are made of wood planks, almost all of them are grooved, most probably meant to match each plank with the next upper or lower one. The planks are fixed to stanchions, some of them are still attached, probably to the frames, under the sand, in the bilge. In one case, one of the stanchions seems to be in relation with a deck beam attached to the starboard side. Some deck beams are partially

[5] AGS, GYM, leg. 492, doc.178

[6] AMR, Libros de Acta, 7 (1604), fs. 133a-133r

conserved and can be documented on the starboard side of the wreck. Not all of them were used to support a deck. Some beams seem to have been used more as structural reinforcements, as they are very close, lower to those used as deck beams. All these structural elements, except the bulkheads, are fixed with iron nails, although most of them have disappeared due to corrosion. No treenails were found at this point.

The underwater body is lead sheathed to avoid biological adherences and to protect the hull timbers from biological attack. The sheets are directly attached to the hull with square iron nails, most of which have disappeared.

Between the central ballast pile and the stern, a group of balusters was found, which maintain a peculiar spiral arrangement that has led us to suggest that they correspond to a spiral staircase, although nothing else we have to support this hypothesis. Manufactured in turned wood, these are very unusual elements in wrecks of the time, because this type of elements, being pieces of limited entity and weight, usually disappear easily after a shipwreck. On the other hand, they are elements widely represented in pictorial works and preserved models of the time.

4 Dendrochronological Analyses on Shipwreck Timbers

In an attempt to place the construction of the ship in an absolute temporal context, samples from different timber elements had been collected in 2012 when the shipwreck was first discovered (San Claudio Santa Cruz et al. 2013). In that campaign, 29 samples were retrieved from both structural elements and timbers from inner compartments, and cargo. The majority of these samples (19) corresponded to framing elements and bulkheads made of deciduous oak (*Quercus* subg. *Quercus*), but the nonstructural timbers were made out of very different species, including spruce/larch (*Picea abies/Larix decidua*, two fragments of a bulkhead and a post), silver fir (*Abies alba*; two planks from inner compartments), chestnut (*Castanea sativa*; two elements of banisters), Scots/black pine (*Pinus sylvestris/nigra*; one plank), poplar (*Populus* sp.; bulkhead), and beech (*Fagus sylvatica*; one barrel stave) (San Claudio Santa Cruz et al. 2013).

Fourteen samples presented more than 70 tree-rings, and although this number is below that which is considered optimal for dendrochronological research (80–100 tree-rings), the samples were analyzed. The results only revealed relative crossmatching between two oak samples and two spruce/larch fragments that derived from the same parent trees. The absence of more relative crossmatching between the oak timbers suggested different procurement areas, and recommendations were made to target more timber elements in future campaigns.

This opportunity rose in the archaeological survey carried out in July 2015 by our nautical archaeology team. Following the recommendations proposed by San Claudio Santa Cruz et al. (2013), new wood samples were collected for dendrochronological research, this time selecting exclusively structural timbers.

4.1 Samples and Dendrochronological Methods

In 2015, a total of 19 timber elements were sampled for tree-ring analysis. Samples were conserved in wet conditions inside plastic bags to prevent them from drying and sent to the laboratory of botany of the University of Santiago de Compostela in Lugo, Spain.

A preliminary inspection was carried out to determine the suitability of these samples for dendrochronological dating. Ideally, samples should contain more than 80–100 rings to deliver statistically robust results, although samples with a lower number of tree-rings can sometimes be considered suitable as well. However, given our objectives, which include the characterization of trees used during the Early Modern Period for shipbuilding, samples with as little as 30 rings, were selected as an exception for tree-ring analysis in order to acquire empirical data regarding growth rates of the trees used for specific elements of the ships. To perform a ring count, the transverse surface of the samples was cleaned with razor blades from the inner to the outermost ring. The presence/absence of pith and sapwood was also recorded. Furthermore, this inspection served to identify some species that show distinct anatomical features in the transverse section, which make them distinguishable by the naked eye. Such is the case for example of the group of deciduous oaks (*Quercus* subg. *quercus*), which show large earlywood vessels placed in a ring-porous disposition and large multiseriate rays, or chestnut (*Castanea sativa*), which is very similar to the group of deciduous oaks, but it lacks the multiseriate rays(Schweingruber 1990). The identification of other species was done by cutting thin slices of wood with razorblades from the transverse, tangential and radial sections of the samples, and observing the anatomical features with an Olympus BX40 microscope. The identification key by Schweingruber (1990) was used to identify the species. Tree-rings were measured in selected samples with a TimeTable measuring device (University of Vienna) coupled with PAST5 software (SCIEM).

4.2 Wood Identification and Dendrochronological Results

Seventeen samples were identified as deciduous oak (*Quercus* subg. *quercus*) and two as pine (*Pinus* sp.) (Table 4.1).

The oak sample RIB01-010W and the pine samples RIB01-014W and RIB001-015W were discarded for further research as they contained 13, 20, and 16 rings respectively.

In this occasion, 10 samples presented more than 70 rings, and five presented the bark edge (last ring under the bark corresponding to the cutting year), or partial sapwood.

Combining these samples with the ones collected in 2012, the final dataset consisted of 48 samples, most of them representing structural elements made of oak.

Table 4.1 Results of the tree-ring analyses. Species: 1, *Quercus* subg. *quercus*; 2, *Castanea sativa*; 3, *Fagus sylvatica*; 4, *Populus* sp.; 5, *Picea abies/Larix decidua*; 6, *Pinus sylvestris/nigra*; 7, *Abies alba*; 8, *Pinus* sp. (possibly *P. pinaster*). Pith: present (+1) / absent (−); bark edge: present (+, LW: latewood, EW, earlywood) / absent (−) / estimated; MRW: mean ring width (mm); σ: standard deviation (mm). Shaded rows indicate pairs of timbers originating from the same tree

Sample number	Type of timber element	Species	Dendro-code	N° rings	Pith	Sapwood	Bark Edge	MRW	σ
Samples collected in 2012									
M02	Inner plank	1	SGRW0020	97	–	0	–	2.17	1.02
M11	Fashion frame	1	SGRW0101	71	–	0	–	3.44	1.75
M05	Inner plank	1	SGRW0040	76(+1)	–	21(+1)	4 ± 3	1.41	0.74
M06	Inner plank	1	SGRW0050	106	–	0	–	1.54	0.84
M15	Inner plank	1	SGRW0140	90	–	17	5 ± 2	1.54	0.37
M09	Unknown	1	SGRW0080	109	–	0	–	1.21	0.36
M16	Unknown	1	SGRW0150	106	–	0	–	1.23	0.32
M10	Unknown	1	SGRW0090	145(+5)	–	26(+5)	7 ± 2	0.90	0.35
M13	Forecastle beam	1	SGRW0120	58	–	23	+(LW)	0.88	0.28
M03	Bulkhead	1	SGRW0030	47	–	0	–	1.30	0.33
M07	Bulkhead	1	SGRW0060	44	–	0	–	1.52	0.81
M12	Bulkhead	1	SGRW0110	43	–	0	–	1.46	0.47
M14	Bulkhead	5	SGRW0130	110	–	?	–	0.93	0.29
M27	Loose Plank	5	SGRW0190	94	–	n/a	–	0.89	0.28
M?	Loose Plank	1	SGRW0010	90	–	0	–	0.65	0.16
M08	Loose Plank	7	SGRW0070	76	–	0	WK?	1.88	0.83
M17	Loose compartment	7	SGRW0161	95	–	n/a	?	1.29	0.36
M21	Unknown	6	SGRW0170	93	–	16	–	1.25	0.47
M23	Barrel stave	1	SGRW0181/2	52/45	–	0	–	0.83	0.16

(continued)

Table 4.1 (continued)

Sample number	Type of timber element	Species	Dendro-code	N° rings	Pith	Sapwood	Bark Edge	MRW	σ
M24	Stanchion?	2	n/a	25(+1)	–	n/a	+(EW)	–	–
M26	Barrel stave	3	n/a	44	–	n/a	–	–	–
M26	Treenail	1	n/a	16	–	0	–	–	–
M04	Starboard plank	1	n/a	10	–	0	–	–	–
M01	Unknown	1	n/a	38	–	6	–	–	–
M18	Bulkhead	4	n/a	?	–	?	?	–	–
M19	Unknown	2	n/a	14	–	n/a	–	–	–
M22	Unknown	5	n/a	36	–	n/a	+(LW)	–	–
M28	Unknown	1	n/a	37	–	0	–	–	–
M29	Unknown	1	n/a	37	–	0	–	–	–
Samples collected in 2015									
RIB01-001 W	Unknown	1	RIB00011	195	–	14	2 ± 1	1.34	1.00
RIB01-002W	Plank	1	RIB00020	61	–	6	–	1.74	0.55
RIB01-003W	Unknown	1	RIB00031	33	+	12	+(LW)	4.45	1.30
RIB01-004W	Beam	1	RIB00040	81	+	10	–	2.50	1.31
RIB01-005W-01S	Wedge cut plank	1	RIB00050	87	–	13		1.98	0.70
RIB01-005W-02S	Frame						–		
RIB01-006W	Beam	1	RIB00060	228	+	44	2 ± 1	0.81	0.46
RIB01-007W	Plank	1	RIB00071	50	–	0	–	1.38	0.34
RIB01-008W	Plank	1	RIB00080	84	–	8	–	0.93	0.24
RIB01-009W	Plank	1	RIB00091	51	–	0	–	2.52	0.83

Sample number	Type of timber element	Species	Dendro-code	N° rings	Pith	Sapwood	Bark Edge	MRW	σ
RIB01-011W	Plank	1	RIB00100	121	–	0	–	0.75	0.27
RIB01-012W	Frame	1	RIB00110	63	+	17	2 ± 1	1.65	0.72
RIB01-013W	Barrel top	1	RIB00121	95	–	9	–	1.08	0.20
RIB01-016W	Beam	1	RIB00130	94	+	25	–	2.14	1.12
RIB01-017W	Chocking timber?	1	RIB00140	52	–	0	–	1.35	0.75
RIB01-018W	Frame	1	RIB00150	202	–	39	2 ± 2	1.01	0.52
RIB01-020W	Wale or outboard plank	1	RIB00160	79	+	0	–	1.71	1.06
RIB01-010W	Plank	1	–	13	+	0	Very fast grown, not suitable dendro		
RIB01-014W	Plank	6	–	20	–	20?	Fragment radial plank, slow grown; potential dendro		
RIB01-015W	Stanchion	8[a]	–	16	–	0	Very fast grown; not suitable dendro		

[a]Identification proposed by Mª Oliva Rodríguez Ariza, dpt. Cultural Heritage, University of Jaen

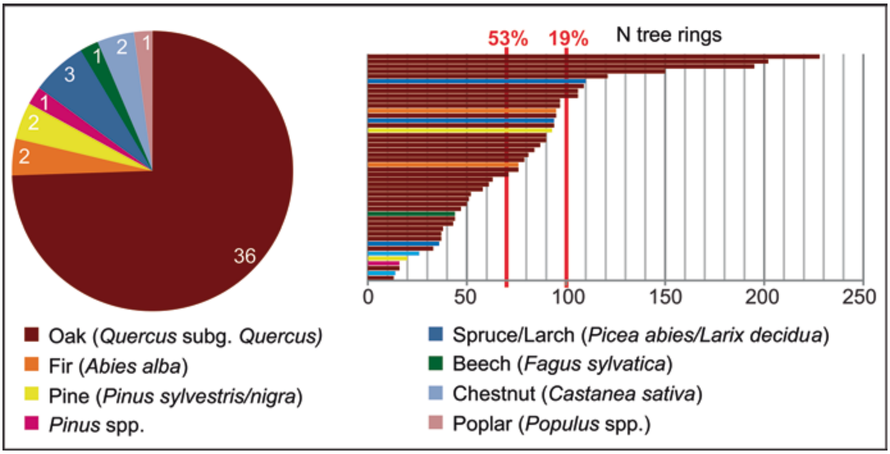

Fig. 4.2 Results of species identification (pie chart) and number of tree-rings (bar graph) present in the *Ribadeo* samples collected in 2012 and 2015

More than half of the samples (53%) contained 70 tree-rings or more, but only 19% surpassed the optimal number of 100 rings (Fig. 4.2).

Crossdating between the samples failed to produce internal crossmatches, which reinforces the hypothesis that the timber may have originated from different procurement areas (San Claudio Santa Cruz et al. 2013). This hypothesis is also supported by the disparity in growth patterns of the oak samples, with some showing mean ring widths of 0.75 mm, and others as much as 4.45 mm (Table 4.1). Using dendroprovenance to try to identify the place where this ship was built is therefore highly problematical.

The comparison of the oak, pine, spruce/larch and silver fir tree-ring series with European reference chronologies, including the newly developed oak chronologies for the Cantabrian Mountains, produced successful results for the silver fir samples, which crossdated with chronologies of this species from Central Europe developed by Büntgen et al. (2011). The fir timber M17 (SGRW0161) dates to 1570 (outermost preserved tree-ring), whereas the outermost ring on timber M08 (SGRW0071) dates to 1580. None of the samples contains the last ring under the bark, therefore these dates can only be considered as *terminus post quem* (date after which the tree was cut). The chronologies dating these samples represent wide areas in Central Europe, therefore it is not possible to pinpoint the provenance of this silver fir wood. The oak, pine and spruce/larch samples remain, for now, undated.

5 Building Up a Hypothesis

At this point three things were clear:

- The shipwreck probably corresponds to a galleon based on the construction features and associated artifacts found in 2011.

- This ship was built after 1580 with wood from different sources, as inferred from the dendrochronological research.
- Three ships sunk in the estuary between 1597 and 1604: the galleon *Santiago de Galicia*, an *urca* and the caravel *Santiago*.

The overall evidence of the wreck in the estuary was pointing toward the remains of a heavily armed vessel of the late sixteenth century, therefore, the *urca* was initially discarded. *Urcas* are known to be northern merchant vessels, but the outstanding scantlings of the framing and dimensions of the planking of the Ribadeo shipwreck suggested that this was a military ship, heavily built and armed, and caulked with watertight decks (San Claudio Santa Cruz et al. 2013). These constructive features should in principle discard the caravel as well, as in Spain they were typically small and light vessels (Martínez Hidalgo 1957). However, one should bear in mind that the names of types of ships varied from one place to another. In 1565 Fernando Oliveira said "The names of species, or manners, of ships and boats, of one type or another, are almost incomprehensible, as much because there are so many of them, as because there have been many changes over time and from place to place; the same species of ship or boat will have one name in Spain, another in France and another in Italy. In Spain they call *naos* what in Italy are called carracks, and in Germany hulks" (quoted in Rahn Phillips 1986, p. 39). Therefore, the caravel *Santiago* documented to have sunk in the estuary on 1604 could have had different construction features than the ones typically shown by Spanish caravels.

Given this scenario, additional aspects were regarded to build up a hypothesis. In terms of the time frame and considering some of the artifacts associated with the shipwreck, the wreck of Ribadeo seems to be connected with the failed fleet of 1596, which lost several ships on the coast of Galicia, particularly in the area of Finisterre. One of these ships is the Punta Restelos shipwreck (Casabán Banaclocha 2015) from which some breech loaders were recovered similar to those found in the Ribadeo shipwreck. Furthermore, some of the breech loaders from the Ribadeo shipwreck perfectly fitted in cannons found in Punta Restelos wreck, suggesting a similar context of origin and supply of the artillery of both ships. The galleon *Santiago de Galicia* belonged to the 1596 fleet. Therefore, having considered all these aspects, we hypothesize that the Ribadeo shipwreck is the *Santiago de Galicia* galleon.

6 Historical Research on the *Santiago de Galicia* Ship

In order to reveal whether the identity of the Ribadeo galleon could be the *Santiago de Galicia*, further historical research was conducted at the Archive of the Museo Naval de Madrid (AMN) and the General Archive of Simancas (Archivo General de Simancas, AGS), in search of documents relating to the history and the construction of that specific ship.

6.1 How and Where Was the Ship Constructed?

Spanish primary sources and contemporary bibliography allowed us to crossmatch historical information from data collected in Spanish archives and information published by other researchers, mainly Thompson (1976). The sources of Consejo de Guerra y Marina and Contaduría Mayor de Cuentas stored at the General Archive of Simancas, and those of the Archive of the Naval Museum in Madrid, have been the primary historical sources researched in Spain.

The outcome of this investigation revealed that in 1589, the Ragusan (Dubrovnik, Croatia) captains Pedro de Ivella and Estefano Dolisti, proposed the Spanish monarch the construction and outfitting of a squadron of 12 galleons of 700 tons each, seven of which were already under construction in "Ragusa, Gravosa, Isola de Mezzo, Castellamare et Vietri."[7] These captains had served in the fleets of the Spanish Monarchy since the 1560s, and in turn, Spanish King Philip II would pay in the realm of Naples the money that the Spanish Monarchy owed them.[8] It is most likely that the King funded these fleets with revenues of the realm of Naples, although it is not possible to state whether the funding originated from incomes of the kingdom of Naples, or from elsewhere. Probably a combination of both took place. As the captains would own the ships, the King agreed in 1593 to pay them a fee and income for serving with those galleons within the royal fleets of the Spanish Monarchy.[9]

Ragusans were skilled seamen in both the Atlantic Ocean and the Mediterranean Sea (Carter 1971), and in the spring of 1589 the Spanish Council of War discussed the possibility of accepting the offer of the captains to construct the 12 galleons.[10] The Monarchy was willing to build warships in order to strengthen its naval power (Thompson 1976; Wing 2015) and the ministers were open to the suggestions brought by the captains. The Council of War agreed to construct and outfit a 12-galleon squadron, which would be composed of seven new vessels, completed with five galleons selected from the Ragusan fleet.[11] The Council planned to construct two light galleons in Naples "according to the measurements and features of the English," and the remaining ships in Castellammare di Stabia, a shipyard located around 30 kilometers south of Naples.[12]

In May 1589, the Council of War had stated that the fleet was "going to be one of the best squadrons of Your Majesty's fleets,"[13] and a month later Philip II accepted the proposal. In October 1589 the Council of War delivered the proposal of the Ragusan captains for constructing and outfitting these twelve vessels in more detail,

[7] AGS, GYM, leg. 303, doc. 29

[8] AGS, GYM, leg. 303, docs. 10, 11, 13, 15

[9] AGS, GYM, leg. 303, doc. 20

[10] AGS, GYM, leg. 303, docs. 10, 11, 13–18

[11] AGS, GYM, leg. 303, docs. 11, 16, 27, 28

[12] AGS, GYM, leg. 303, doc. 12

[13] AGS, GYM, leg. 303, doc. 15

stating again that 7 of the 12 vessels should be new constructions.[14] Disclosure and signature of the contract took place on February 20, 1590,[15] but the document stated that of the 12 galleons, only six instead of seven would be of new construction. The contract specified the duties and rights for both sides. The captains committed to the production of a squadron composed of twelve warships to serve the King for an initial period of 5 years. The construction contract ran from January 1, 1590 to December 1594, and the captains outfitted the fleet (including the artillery, rigging, and recruitment of a crew of 20 people per 100 tons) within 4 months of having received the notification by the King's officers being similar to other contracts (Thompson 1976, pp. 200–205; Goodman 1997, pp. 30–32, 126–129). Finally, the captains and their associates agreed on building six new galleons, instead of the seven they had offered initially,[16] and lease them to the King.[17] In return, Ivella and Oliste would be appointed general captain and admiral respectively of the squadron, under the command of the general captain of the fleet, and would receive a monthly income in Naples.[18]

According to the documentation in 1589 they offered to serve with 12 galleons, seven of them would be of new construction. In May, the captains Pedro de Ivella and Estefano Dolisti stated that seven galleons were under construction in "Ragusa, Gravosa, Isola de Mezzo, Castellamare et Vietri".[19] The contract or *asiento* they signed with the Spanish Monarchy stated that of the 12 galleons, six of them would sail for first time.

In October–November 1590, captain Ivella departed from Madrid to Naples, from where he wrote letters providing information regarding the construction process. In January 1591, three galleons capable of sailing the Atlantic were launched, and construction of the remaining four was near to completion. However, Ivella did not specify which ones were launched nor where. Ivella was arranging materials to construct another two ships in Naples, three ships were launched and another four were being built, two of them in Naples following English examples, that were very good sailing vessels,[20] following the English ship measurements, with the expectation that this design would produce vessels with an extraordinary sailing speed.[21] According to historical sources, for the construction of these galleons in the kingdom of Naples timbers were felled during the waning moon of January 1591 and seasoned in February for the construction of the two additional galleons. The construction of these ships continued in May, and finished by July of that same year.[22]

[14] AGS, GYM, leg. 303, doc. 11, October 231,589, further details in doc. 17

[15] AGS, GYM, leg. 303, doc. 20

[16] AGS, GYM, leg. 303, doc. 20, clause 11

[17] AGS, GYM, leg. 303, doc. 20, clauses 1, 2 and 11

[18] AGS, GYM, leg. 303, doc. 20, clauses 6 and 12

[19] AGS, GYM, leg. 303, doc. 29

[20] AGS, GYM, leg. 317, doc. 194

[21] AGS, GYM, leg. 317, doc. 194, Naples, January 201,591

[22] AGS, GYM, leg. 318, doc. 176, February 151,591; leg. 321, doc. 324

Thus, it is most likely that Pedro de Ivella and his partners constructed seven new galleons in 1591. By 1594, 9 of the 12 galleons had been constructed or outfitted.[23]

According to the historical sources stored in AMN, the wood used for the construction of the ships, including the *Santiago de Galicia*, was sourced in different places: Monte Gargano in South Italy, nearby Naples, and Albania supplied construction timber, but the masts originated from Calabria, in the South of Italy, and the Peninsula of Istria.[24]

6.2 The Performance of the Squadron (1591–1597): From the Shipyards to the Seabed

The new squadron was most likely made up of 12 warships. However, in 1591 the ships were mainly used as merchantmen to carry wheat, wool, and other commodities.[25] In the ensuing year, it seemed that the ships remained inactive in Southern Italy, a circumstance that Ivella could not afford because he needed funding, both to maintain associates close to him, and also to ensure the economic viability of the squadron. Thus, in April 1593 he offered to the Spanish Crown his ships when he realized that the Merchant Guild of Seville (*Casa de Contratación*) had set up negotiations with the Genovese to build galleons to protect the Indian trade.[26] Ivella channeled his pretensions through the Duke of Medina Sidonia, who backed the captain by writing a long report supporting the convenience of electing the squadron of Ivella to protect the trade.[27] In the meantime, Ivella continued offering the service of the squadron to the King. During the winter of 1594 Philip II issued orders to his viceroy of Naples to extend the original contract signed in 1590 with Ivella.[28]

Consequently, the King had at his disposition a nine-galleon squadron, including the galleon *Santiago de Galicia*, which was acknowledged as the "*Almiranta*" of that squadron. Jacome Juan de Polo was the captain and owner of the vessel. The economic records of the ships are stored in Simancas and they clearly state that Jacome Juan de Polo was enlisted by contract with the *Galleon Santiago* from 1594 to 1597.[29] From the outset of 1595 to July 1596 the captain received considerable funds from different hands in Naples, Seville, and Lisbon to pay the crew, supplies, and transportation of materials. During June and July 1596 carpenter works were carried out in Lisbon. In the accounts of these works many materials were specified, such as 36 planks from Prusia, 96 planks from ordinary pine tree from Flanders, 12

[23] AGS, GYM, leg. 303, docs., 470–471

[24] AMN, Colección Sans Baturell, Ms. 396, art 5, n° 53, p. 225–226

[25] AGS, GYM, leg. 324, doc. 213, August 31,591, Naples

[26] AGS, GYM, leg. 387, docs. 610–612, Naples 9 April 1591

[27] AGS, GYM, leg. 387 doc. 609, May 301,593

[28] AGS, GYM, leg. 388, doc. 301

[29] AGS, Contaduría Mayor de Cuentas [hereafter CMC], 3° época, leg. 2556

squared pine sticks, two oaken planks of 28 codos (One codo was 57.46 cm), and 24 small pine bars. Don Rodrigo de Cieza, who held the office of *tenedor de bastimentos* in Lisbon, also handed from July to October 1596 a significant amount of timber of pine and oak. Amidst others, the Spanish Monarchy paid 150 *reales* for "an old pine tree from Corcubión of 33 codos in height and half wide" another 276 reales for "a new pine tree, 30 codos long and two thirds of a codo wide, six from the feet, and six with half an elbow from the top" 150 reales for "another new pine tree, 27 codos long and a third wide, measured at six codos from the top and six codos from the *coz.*"[30] According to the economic records, it is most likely that in October 1596 Juan Jacome Polo sailed from Lisbon to Galicia with the ships, because that month in 1596 he received 220 ducats "*del pagador por cuenta de libranza del Adelantador Mayor de Castilla, pagador general de la armada.*" The Crown paid another 2.176 *maravedíes* for the carpentry works (*maestranza*) undertaken in El Ferrol (Galicia, Spain) from April 6 to 27, 1597, confirming the theory that the wood has come from several places.

Similar payments were done for further *maestranza* works undertaken in Ferrol from April 28 to May 17, June 30 to July 20, and August 10 to 30, 1597.[31]

Juan Jacome Polo outfitted the ships in Lisbon, and they were consequently remeasured as they had been originally in Naples.[32]

In 1597, the Galleon *Santiago de Galicia* was sailed through a huge storm, which dispersed large part of the fleet that Philip II had sent out against England.[33] The *Santiago de Galicia* was acknowledged as a very sturdy vessel, and appointed to carry 91,000 ducats (Fernández Asís 1943: 338). Afterwards Bernabé de Pedroso documented that the *Santiago* had reached the Eo estuary, together with two *urcas*, "*…so damaged that it is likely a miracle, people on board came badly and ill as a result of the hard work they have had…*"[34]. Later it was learned that the galleon

Table 4.2 Measurements of the galleon *Santiago de Galicia* as reported in historical documents

Measurement	Codos	Metres
Keel	44.50	25.36
Weather deck	61.00	34.77
Carling	60.00	34.20
Beam	20.50	11.68
Depth	13.50	7.69
Flat of the floor timber	7.25	4.13
Aft Runs	7.50	4.27
Fore Runs	2.00	1.14

[30] AGS, CMC, 3° época, leg. 2556

[31] AGS, CMC, 3° época, leg. 2556

[32] AGS, GYM, leg. 303, doc. 20, clause 2

[33] AGS, GYM, leg. 490, doc. 431, 1597

[34] (AGS, GYM, leg. 491, doc. 190)

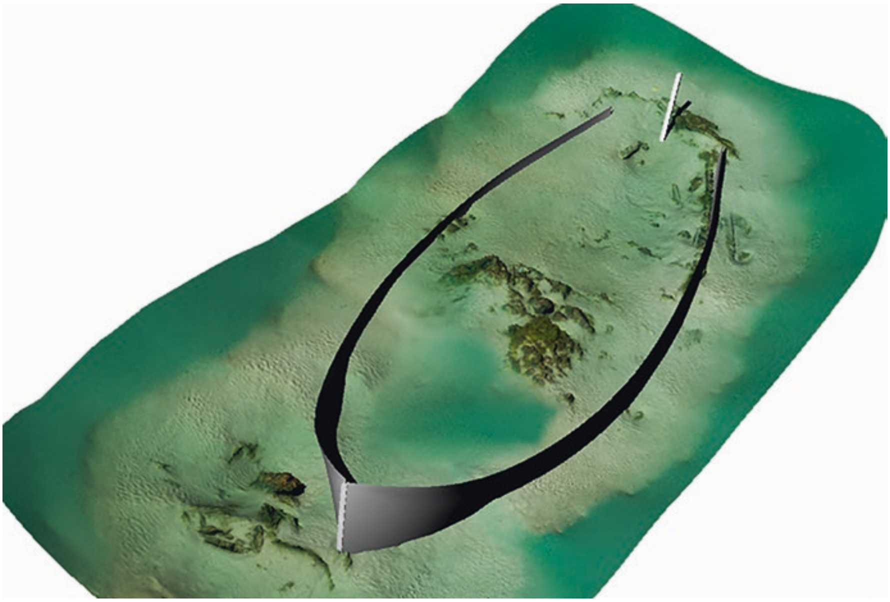

Fig. 4.3 The photogrammetric model of the Ribadeo wreck, matching the archaeological remains of the Ribadeo wreck to the hull lines of the hypothetical reconstruction of the *Santiago de Galicia*, based on historical documents. (Photogrammetry by Christin and Brandon Mason. Rhinoceros modeling by Selina Ali and Adolfo Miguel Martins)

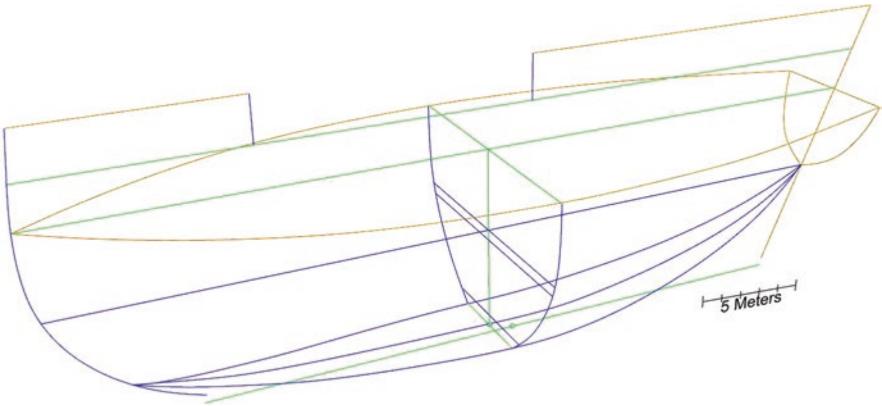

Fig. 4.4 Reconstruction of the *Santiago de Galicia* ship, based on historical documents. Colours represent origin of sources. Green for direct evidence from historic documents, blue for estimated dimensions based on the overall basic dimensions in green, brown is indirect evidence of the time, collected from examples of ships specified in the Spanish *Ordenanzas* (Rhinceros 3D modeling by Selina Ali and Adolfo Miguel Martins)

Santiago de Galicia had encountered four enemies and fought against the Flemish and English, under their musketeer's fire.[35] Damaged by the naval battle and fighting the storm, the *Santiago de Galicia* hit the sandbanks at Ribadeo and was beached, although it was not considered lost by the authorities. The Crown sought to recover the coins and some of the supplies that were on board. It is most likely that this was done, as some of the ministers of Philip II praised the cooperation of Ribadeo's inhabitants.[36] In November 1597 there were delivered payments in Ribadeo, like the 1500 *reales* "que Tomás Blanco capitán de este galeón recibió en la villa de Ribadeo de los dineros del cargo del pagador general Juan Pascual por mano de Lope García de Tinoco."[37] In a letter sent to Philip II, Jacome Juan de Polo blamed the officers governing the vessel for their bad seamanship, which had led to the loss of the ship (Casabán Banaclocha 2015): "Due to poor governance, the officers lost her in the village of Ribadeo."

6.3 Construction Features and Proportions of the Santiago de Galicia Galleon

An historical document describing the dimensions of the ship was found in the *Archivo del Museo Naval de Madrid*[38] (Table 4.2; Figs. 4.3 and 4.4). Dimensions given in this document are provided in *codos.* The measurement conversion used here is based on the sixteenth-century *codo de ribera* from northern Spain. This unit of measurement was the equivalent of 57.46 cm(Casado Soto 1988, pp. 58–67; Grenier et al. 2007 III, p.17). It should be kept in mind that such measurements changed from time to time, and also from one shipyard to another. The conversion used here also follows the research of Casado Soto (1988, pp. 58–73).

According to the document, the 12 galleons fleet combined measurements from different origins, following English, Bizcayan, and Ragusan shipbuilding traditions. This means also that these shipbuilding traditions influenced the shape of the hull. Particularly, the proportions of the *Santiago de Galicia* had a beam to keel ratio of 2.17, a length to beam ratio of 2.93, a depth to length ratio of 4.44, and a depth to beam ratio of 0.66.

In trying to find an archaeological example of a caravel, the first scholar to propose the concept of Iberian-Atlantic ships, Thomas Oertling, agreed that "It was something of a disappointment to discover that the difference between a caravel or a *nao*, a *nao* and a galleon, and so on, could be not discerned based on the construction features" (Oertling 2004, p. 133).

In this case, the example of the Ribadeo wreck will be a revealing source to ponder the question of what was the ship. Conceptual approaches trying to find consistent "ship types" have proved to be problematic and there has been a great

[35] AGS, GYM, leg. 491, doc. 139

[36] AGS, GYM, leg. 491, docs. 146, 226, 335

[37] AGS, CMC, 3° época, leg. 2556

[38] (AMN, Colección Sans Baturell, Ms 396, art 5, n° 53, p. 225–226)

terminological confusion. "Ship types" represent permanent concepts, but ships were not permanent throughout space and time. In this case, to determine whether the Ribadeo was a galleon, a caravel or an *urca*, would be rather difficult. Due to the lack of fully preserved examples, the archaeological remains rarely have a high level of preservation. The words *caravel, urca,* and *galleon* were used in different languages, but they did not represent a coherent and consistent shape of vessel throughout time and space. For this reason, if the ship was to be a galleon, *urca* or caravel, these archaeological finds would not be able to clarify the question, due to the similarities between ship types, but also due to the lack of consistency and variety between wrecks. Therefore, the Ribadeo vessel was not a standardly built ship type and therefore it is likely that it represents a unique vessel of the time.

7 Matching the Historical and Archaeological Data

In order to test whether the wreck found in 2011 could correspond to the *Santiago de Galicia* we combined a photogrammetric survey undertaken during the archaeological campaign in 2015 with a 3D model based on historical documents for the *Santiago de Galicia*. The aim of this method was to test whether the shipwreck matched the historical measurements. The archaeological remains and the hull lines on the seabed were used to match the reconstruction of the shipwreck with the photogrammetric data, providing a hypothetical shape and size. In 2015, the main wale of the ship was observed located at the height of the main deck or first deck, on the widest point of the ship. The height of the main deck offered a reference for positioning the 3D model relative to the archaeological remains.

On the starboard side, the original measurements were very similar to the reconstructed hull lines represented in Fig. 4.3. In this figure, the starboard side frames and hull line can be seen, with the bow of the ship pointing northwards. The hull lines matched the reconstructed 3D ship at the height of the widest deck (Fig. 4.4) or the first wale, and the frames along the starboard side of the wreck.

In the reconstruction in Fig. 4.4, different parts of the ship can be seen colored depending on the source used for interpretation. From top to bottom we have: the bow and stern castle decks in brown, based on the Spanish *Ordenanzas* from the early seventeenth century, which represent an estimate of the potential height of the ship in these upper structures; in green, the weather deck; the lower gun deck, in the middle showing the widest point of the ship or beam, as inferred from the measurements reported in historical documents for the *Santiago de Galicia*; and underneath, in blue, the orlop deck and the bilge at the very bottom (in blue on the sides, black in the middle), which was estimated taking as reference the measurements in green, such as the turn of the bilge line, the height of the first beams and possible height of the ceiling of the bilge. The transom panel can be seen at the right (in brown), was inspired by how the transom panel is calculated in the Spanish *Ordenanzas*. The stem post at the left (in blue), was also an estimate from the measurements of the historical document in green. The turn of the bilge line is marked at the very bottom of the hull as a curved blue line. The keel is situated underneath the bilge area, in green. The stern post is on the left side, in brown. The reconstruction and relationship of these elements was carried out based on archaeological publications and historical data on sixteenth-century shipbuilding and some of the early seventeenth-century *Ordenanzas* and treatises (Escalante de Mendoza 1985; Grenier et al. 2007 III; Hormaechea et al. 2012, pp. 246–294).

The photogrammetric survey and the 3D model based on historic documents, once superimposed, indicate that the dimensions of the wreck itself and the estimates from the historical reconstruction were very similar. Although these theoretical reconstructions cannot serve to state with certainty that the shipwreck is the *Santiago the Galicia*, at least they do not rule out the ship as a potential candidate.

8 Have We Identified the Ship with a Multidisciplinary Approach?

Our multidisciplinary research has led to the hypothesis that the Ribadeo shipwreck corresponds to the *Santiago de Galicia* galleon of Ivella's fleet, built in Castelamare di Stabia, nearby Naples (Italy) around the early 1590s. According to the historical sources, the *Santiago de Galicia* galleon sank in Ribadeo in AD 1597. The artifacts found around the shipwrecks together with the archaeological data, that is to say the measurements and construction features, indicate that the ship was very likely to be a galleon, and a crosscheck of the archaeological data and the measurements provided by historical sources for the *Santiago de Galicia* ship does not refute the hypothesis that this is the galleon that sunk in Ribadeo. As noted, the economic records of Juan Jacome Polo demonstrated that in November 1597 the ship was in Ribadeo.[39] However, there are several aspects to consider that hamper the identification of the shipwreck with certainty.

We have not found in historical documents information about the measurements and dimensions of the *urca* and the caravel *Santiago* that sunk in the estuary respectively in 1597 and 1604. The lack of such documentary information hampers carrying out the construction of a theoretical model for both ships to be crossmatched with the archaeological reconstruction we have made for the shipwreck. Therefore, those ships cannot be ruled out based on actual historical documents and only if the shipwreck is fully excavated, will we be able to improve our model and assess whether its dimensions could correspond to the ones reported for the *Santiago de Galicia* galleon.

Dendrochronological research on 48 samples has resulted in the dating of two silver fir planks from the inner structure after 1580. The natural distribution of this species comprises mostly central Europe, the Pyrenees, Balkans, and Carpathian Mountains, therefore this wood could have been available in Adriatic, Central, and

[39] AGS, CMC, 3° época, leg. 2556

Western Mediterranean shipyards as well as in North European ones. Consequently, the provenance of this wood cannot serve as an indicator of the shipyard in which the ship was built. The absence of matches between oak samples collected in both campaigns suggests that the wood from the Ribadeo shipwreck originates from different areas. This would be in agreement with the information found in historical sources about the different provenance of the wood used to build the *Santiago de Galicia*. However, the lack of well-replicated oak reference chronologies for the historically identified areas (southern Italy and Albania) impedes establishing the date and provenance of the oak timbers by dendrochronological methods. More samples should be collected from the shipwreck in order to achieve mean curves from different timber elements, as they have higher chances to be crossmatched with reference chronologies than individual samples. Furthermore, future dendrochronological work should focus on collaboration with Italian researchers, and on the development of tree-ring reference chronologies for Albania and the rest of the Balkans, one of the remaining gaps in European dendrochronology.

These findings are the preliminary conclusions of an ongoing investigation and offer many potential lines of research inquiry for the future. The archaeological campaigns carried out so far have only involved prospective works. An archaeological excavation would be the desirable step forward to finally confirm the identity of the ship. After the 2015 study, the wreck was covered by a mesh that proved to be effective against the estuary's currents. However, such temporary preservation interventions could not be considered lasting. The preservation of the shipwreck is incompatible with the present activity of the harbor and is constantly challenged by the mechanical influence of strong tidal currents, merchant traffic, and biotic organisms that affect its integrity. Short-term action is needed to protect the wreck in this endangered area. In this way, not only the shipwreck, but its full history can be preserved as valuable heritage and as source of data for future research.

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Chapter 5
The Belinho 1 Shipwreck, Esposende, Portugal

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Abstract In the winter of 2014, João Sá, Luís Calheiros, Alexandre Sá, and Emanuel Sá communicated the finding of an important set of ship timbers and artifacts washed ashore at Belinho, Portugal, after an exceptionally large storm. Between 2015 and 2017, a succession of storms pushed more timbers and artifacts ashore. All timbers and artifacts were recovered, conserved, and curated by the archaeologists of the Esposende municipality. This chapter describes the present state of the research on this shipwreck and the collaboration between a large and diverse community of domain experts and the participating public.

1 Introduction

The Portuguese northwest coast has suffered the impact of a gradual process of erosion in the second half of the twentieth century. This phenomenon revealed several underwater archaeological finds in the Esposende municipality in the north of Portugal. The Belinho beach in particular has been affected by a process of climate change, suffering mainly from coastal erosion, which since the second half of the twentieth century has impacted the northwest of Portugal (Granja et al. 2013; Granja and Pinho 2015).

The beach morphology is characterized by a pebble crest, parallel to the frontal dune, with a steep slope with a variable height and width, which extends from the base of the dunes to the rock outcrops in the lower part of the beach. Over the last decade, a remarkable set of archaeological discoveries has been revealed in the municipality of Esposende (Almeida and Magalhães 2013).

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These finds are directly associated with the geographic position of the coast of Esposende, where shallow basins abounded (Almeida 1979, 1986). The present configuration of the Belinho beach encompasses a pronounced thinning of the sediments in the surf area. This has increased the surf energy, channeled between rock outcrops, and destabilized the archaeological site. The appearance of the ship remains dating to the sixteenth century in the present intertidal area suggests that the now eroded beaches were of relatively recent geological formation (Almeida et al. 2020, p. 187).

Due to superstorms—*Hercules* (December 2013–January 2014) and *Doris* (February 2017)—hundreds of fragments of Roman amphorae (Belinho 2 site), ship timbers, and post-medieval artifacts (Belinho 1 site) were washed ashore at Belinho beach (Almeida et al. 2017).

The process of loading the beach and subsequent erosion will be the subject of a detailed study, which will allow us to understand the process of loss of the ship and the formation of the archaeological site. It is not, however, to be ruled out that this site was previously known. Archaeologists Ivone Magalhães collected information about two bronze guns in this area, during the 1990's implementation of the draft Archaeological Chart of the area (IPARMALE).

2 Belinho 1 Shipwreck

One of the most recent discoveries dates to 2011 when João Sá, a local sculptor, found some iron concretions on the Belinho beach intertidal zone, which he used in his creative work. Two years later, however, some of these concretions cracked and opened, revealing what was hidden inside: iron cannonballs. Nowadays, this archaeological site is known as Belinho 2.

In the winter of 2013, these discoveries gained a new context. Not very far, 1.75 km north from Belinho 2, during a regular morning walk in the low tide, a relative of João Sá, Luís Miguel Calheiros, found something "that looked like metallic helmets" and some timbers scattered along the seashore. When they returned to the beach, they found hundreds of ceramic fragments. João Sá contacted the Esposende municipality to report these findings. He also declared the findings to the Portuguese National Centre for Nautical and Underwater Archaeology/Directorate General of Cultural Heritage (CNANS / DGPC).

As already published elsewhere(Almeida et al. 2020; Martins et al. 2020a), the timbers and artifacts from Belinho beach were identified by CME archaeologists, Ana Paula Almeida and Ivone Magalhães, as findings of exceptional importance, coeval among themselves, and dated to the sixteenth and seventeenth centuries. More than a hundred pewter and brass plates and bowls, some bronze artifacts, a fragment of chain mail, an iron axe with a wooden handle, stone cannonballs, fragments of wood and metal, remains of a sword scabbard coated in leather, and ship timbers, all seemed to date to the middle sixteenth century.

The site was given the designation Belinho 1, and the timbers and artifacts were collected and stored by the City Council of Esposende, which provided a place for storage and immediate conservation for the findings, which proceeded with their cataloging and implemented a conservation plan for the waterlogged material. In the first phase, meetings were held with conservation technicians from the Laboratory of the Archaeology Office of neighboring Vila do Conde municipality, and the Museum Network of the Sea of Esposende, as well as CNANS, whose input helped the development of the conservation plan. Protocols were established between Esposende, through its Cultural Heritage Service, and the Laboratory of Conservation and Restoration of the Archaeology Office of Vila do Conde, and the Laboratory of the Archaeological Museum D. Diogo de Sousa, in nearby Braga, to establish a collaboration that provided the best possible conservation care, decision-making, and the implementation of good practice rules in all required conservation work of waterlogged artifacts.

The shipwreck area was also subject to topographic registration using the Topography Service of the Esposende municipality, and georeferencing of the area of dispersion of the artifacts was carried out.

After the site was communicated to the Esposende municipality a series of rescue actions were implemented, with the precious help of the finders João Sá, Luís Calheiros, Alexandre Sá, and Emanuel Sá (Fig. 5.1).

Esposende municipality archaeologists Ana Paula Almeida and Ivone Magalhães identified these findings as having exceptional importance and concluded that they had two distinct chronologies: Roman amphorae fragments—this new archaeological site is known as Belinho 3—and post-medieval artifacts and disarticulated ship timbers, undoubtedly belonging from an unknown shipwreck dated to the sixteenth–seventeenth centuries—known as Belinho 1.

Fig. 5.1 Location of the Belinho 1, 2 and 3 Sites (Ana Almeida)

A joint project was designed between CME's Cultural Division, the Institute of Archaeology and Paleosciences from Universidade Nova of Lisboa, and the ShipLAB at Texas A&M University (TAMU), in cooperation with the finders.

Urgent measures were taken to prevent damage or loss—either through the looting of exposed materials or by the sea dynamics—of the hundreds of artifacts and dozens of ship timbers that washed ashore after the storm. The rocky nature of the bottom, the poor water visibility, and the energy of the sea made the attempts to locate the shipwreck site difficult. Therefore, during the short period of time of the low tide and often under hard conditions, a teamwork effort was set up between João Sá, Luís Calheiros, Alexandre Sá, and Emanuel Sá—all relatives and habitual visitors of this beach—and the CME archaeologists Ana Paula Almeida and Ivone Magalhães.

Between 2015 and 2017 the beach was under daily vigilance, and a series of storms resulted in more wreckage being washed ashore. Hundreds of artifacts such as pewter plates, copper plates, candlesticks, and a small number of personal artifacts were collected—swords, axes, or chainmail—as well as stone cannonballs and ship ballast. The CME's Cultural Division Services recorded and took care of the artifact collection (Almeida et al. 2020; Martins et al. 2020b).

A multidisciplinary team, funded by the CME and a European Union Marie Curie Grant (PITN-2013 GA607545), recorded and cataloged the timbers that had washed ashore until that date(Castro et al. 2015).

Some loss of artifacts and ship timbers was experienced again in 2017, due to the "Doris Storm." On April 24, 2017, during one of the lowest tides of the year, the water conditions improved and finders Alexandre Sá and João Sá detected two cannons and one anchor. In the next days, Alexandre Monteiro and John Sexton made recognition dives that confirmed the presence of the anchor and the two bronze cannons. These bronze guns were found to be two similar demi-culverins with octagonal sections, typical from the first half of the sixteenth century. They have a 7 cm bore and are 2.65 m long and the body is simple, without rings or ogees. Their tulips are octagonal as well, and flair out, suggesting that they were not cast for use aboard ships, shooting through gunports (Almeida et al. 2020, pp. 197–8). They are similar to the one found in the Oranjemund shipwreck, on the Namibia coast. Two iron guns were also recorded, one clearly a breech-loader, and another larger, muzzleloader, and highly concreted.

These dives also allowed the identification of other artifacts, littering the bottom over a substantial area: two iron cannons—one clearly a breech-loader and another larger and highly concreted one—large sets of coherent timbers, and several artifacts—pewter plates and stone cannonballs—belonging to a shipwreck site. The mystery of Belinho 1 shipwreck location was solved.

In May 2017, a series of geophysical surveys were carried out on the shipwreck area by a team from the Laboratory of Systems and Underwater Technology (LSTS) of the Faculty of Engineering of the University of Porto (FEUP), with remote sensing equipment, namely with AUVs equipped with side-scan sonar and magnetometer. Dives took place also to inspect the anomalies detected by geophysics or indicated by the surveyors (Almeida et al. 2020).

Maps were generated from the data obtained, which revealed an area of cultural material concentration and helped the team understand and implement a strategy for the site. The resulting maps pinpointed an area of accumulation of cultural material and helped the team understand and implement a mapping strategy for the site. Simultaneously, archaeologists tried to locate structures and collect materials exposed at low tide on Belinho beach and pinpoint their coordinates. A visual underwater survey was carried out in the surf zone by scuba divers and segments hull structure and artifacts were also observed and positioned.

Between May and June of 2018, during monitoring dives, it was possible to identify and record by photography and video a total of eight iron guns, georeferenced by the topographic team of the Esposende city council.

All eight iron guns present a ferrous oxide coating. Gun number eight seems to have some timber associated with, which might belong to a gun carriage. The two bronze guns showed a light green patina, which indicates active corrosion.

3 Artifacts

Between 2014 and 2015, the Belinho 1 site was under daily visual surveillance, up to the water line and during the low tide, which was reinforced whenever there was a strong sea and low tide of less than 0.50 m. As a result of the strategy implemented, and as long as the tide allowed, the registration and systematic collection of the archaeological remains were carried out regularly.

The first analysis of the materials recovered, associated with the site of the Belinho 1 shipwreck, dates back to December 2014. The artifacts were divided into categories. Metals are the most abundant and were separated between copper alloy (pewter and brass), ferrous metals, and lead. Other artifacts are made of stone, ceramics, and wood.

A collection of over 628 artifacts was found in the intertidal zone over the winter months. These do not include wooden parts of the ship, led fragments, or stone ballast (which we believe to be parts of the hull's construction) or objects directly related to navigation, thus the number of finds is much larger. The objects found on the beach correspond mostly to pewter, brass, and lead objects. The publication of cargo and material culture aboard Iberian wrecks is not frequent and rarely reported with a monographic objective. This is one of the main reasons that make the study of the Belinho cargo so important when combined with the analysis of the ship's building structure.

3.1 Pewter Objects

The most frequent items are pewter plates, with 453 fragments and 254 vessels (MNV). Morphologically the plates have a short flap and a round bottom. Seven different sizes of plates were recognized with diameters ranging from 14 to 47 cm, although the most abundant have a rim diameter of 24 cm. A considerable quantity, attending to the size of the collection, has makers' marks with approximately half a centimeter. Three porringers with two floral handles and a rim diameter of approximately 17 cm were also recovered. Two candlesticks made of pewter reveal that this cargo was carrying what was commonly produced in Northern Europe. A flat object seems to be the cover of a book or the lid of a box. Two pewter spoons were also found as well as a tankard missing its lid.

Pewter objects are among the most frequent finds in Early Modern Age wrecks. The most recognizable is by far the so-called Pewter Wreck, sunk off Punta Cana somewhere in the sixteenth century, with more than 1200 objects made in this copper alloy (Roberts 2013), or *La Belle* (1686) with the discovery of over one hundred pewter artifacts (Bruseth and Turner 2005, p. 99).

Similar objects were discovered in *Mary Rose* (Weinstein 2005) or the Great Armada wrecks (Martin 1975, p. 144). Pewter bowls are less frequent but recognizable through their floral handles. Only three of these objects have been recovered thus far in the Belinho shipwreck. These are found in other shipwreck sites, such as the one of the Portuguese Namibian wreck (Knabe and Noli 2012, p. 185) but also the 1545 *Mary Rose*, and the Alderney wreck sites (Parham and Cousins 2018), dating from the second half of the sixteenth century. These objects are found in wrecks either as cargo or objects used in daily activities. Their level of resistance to breakage made them the perfect artifacts to resist the unstable environment inside any ship. Around 40 of these objects were found inside *Mary Rose* (1545), (Weinstein 2005, p. 424), the supposed *Bom Jesus* (1533), and other Portuguese wrecks, such as the Pepper Wreck (1613) (D'Intino 1998, p. 222), some of the Great Armada wrecks (1588) (Martin 1975, p. 144, Fig.7), and a few other shipwrecks, including the presumed 1503 *Esmeralda*(Casimiro 2018), among others, although not in high amounts.

Of the marks identified by Ana Valentim, conservation and restoration specialist from the Archaeology Office of Vila do Conde, and by Christopher Dostal, Texas A&M University conservator associated with the project, one appears to contain a crown and a rose (Gadd 1999). The crowned rose is a frequent mark since the sixteenth century on pewter plates demonstrating the quality of production (Cotterell 1963). Other marks, most abundant, contain a crowned hammer. These crowned hammers have many variants, depending on the producer. In one case it is possible to recognize two manufacturer initials, "U" and "C," a brand type frequently used in Dutch or German productions. Crowned hammers are represented in Belgium at the end of the fifteenth century (Greenland 1904, p. 94), in the sixteenth century in Switzerland, and in the seventeenth century in Scotland (Fiske and Freeman 2016) (Fig. 5.2).

Fig. 5.2 Pewter and brass objects

3.2 Brass Artifacts

The number of brass objects is smaller, with 132 fragments. These are larger in size since their average size is almost 50 cm in diameter. From the 34 vessels recovered (MNV) only one can be interpreted as a basin and seven plates present decoration. These correspond to what is usually known as alms dishes and are seldom if ever found in shipwrecks. The most important production center of these objects was Nuremberg, although they were also produced in other parts of Germany, the Netherlands, and the Low Countries, although in smaller quantities (Martins 2010, p. 26). These are plates decorated with a large variety of motifs. Associated with the Belinho wreck are five variants. Floral decoration at the center, St. Christopher with a boy on his shoulders holding a walking stick, and St. George fighting a dragon. Another plate is decorated with an Old Testament scene where Joshua and Caleb transport a cluster of grapes, harvested in the valley of Eshkol. Another plate shows a scene where Adam and Eve are tempted by the serpent in paradise. Some of these have sayings: DER.I.N FRID.GEHWART—*He who brings peace* and HILF. IHS. XPS.UND.MARIA—*Jesus Christ and Mary.*

One pot was found in 2016 with no handles but the evidence of once having a lid. Its use is debatable. While all the other brass artifacts have a specific function, this one could be just a storage vase. One brass candlestick was also recovered in 2017.

This diversity of religious scenes seems to associate them to environments where these would have been used such as churches (Gadd 2008). There are documents that reveal that these objects were frequent in Iberian Catholic churches used to collect money among people or even to perform rituals such as baptism and the anointing of the sick (Martins 2010).

3.3 Ferrous Metals

The state of conservations of the seven objects made from iron is delicate and the concretions around them did not permit a visual identification. It was through X-ray that the identification was possible. Two parts of axes belonging to two different objects and at least two swords (five fragments) with the pommel, handle, and guard. The state of conservation of these weapons did not allow us to go beyond general recognition of their function, and it is not possible to state if any of these objects was part of the cargo or tools and weapons used by people on board.

3.4 Stone Cannon Balls

To date, 32 stone cannon balls have been recovered on the Belinho beach. Although the petrological analysis is pending, they appear to be cut of granite, limestone, and volcanic rocks other than granite, revealing different origins. Diameters vary between 7 and 9 cm on the smaller ones and between 12.5 and 18 cm on the larger ones.

3.5 Ceramics

Only one single shred was found on the beach. The paste is light buff and covered with white tin glaze, decorated with cobalt blue lines. The fabrics and decoration suggest that this is an Iberian production made in the sixteenth century, although the state of conservation of its surface does not permit a more refined chronological definition (Casimiro 2013). The object corresponds to a carinated bowl.

The coherence of the collection, especially the pewter and brass objects, suggests that they were most likely loaded in one single moment, in one port, or in nearby ports. The pewter plates reveal the same production technology, and some of them bear similar or very similar marks. It is not easy to date pewter objects since these are very similar from the fifteenth to the nineteenth century, with some changes in the rims. Nevertheless, the crowned hammer seems to indicate a sixteenth-century production. As for the alms dishes, these are easier to situate in a narrow chronology. Although these are highly produced from the sixteenth to the late eighteenth century in several places, the styles of these objects are quite similar to the productions made in the sixteenth century (especially between 1520 and 1580). Although plates are a regular find in European shipwrecks used on daily activities, the exceptionality of the brass plates seems to indicate that these were part of the cargo.

Being a sixteenth-century wreck, it seems that the value of its cargo was enormous. Church inventories reveal that alms dishes were among the possessions of religious institutions and their value was elevated (Martins 2010). In the inventory of the possessions of a rich Portuguese, D. Teodósio (c. 1505–1563), there are mentions of several pewter and brass objects. This was a noble and rich house, and the amount of pewter and brass indicated the social base of consumption. Nevertheless, it is interesting to see that the average value of a small plate (possibly the ones with 24 cm) was around 60 *reis*. As for the brass objects, their value was higher, and the average basin would be worth around 200 *reis*. As a comparison, at this time, porcelain or white bowl (such as the one found here) would be worth around 60/75 *reis* (Hallet and Senos 2018).

Terrestrial discoveries of pewter objects are rare. Metals are seldom found in domestic contexts especially due to their possibility of being recycled. Nevertheless, if these were frequent inside Iberian houses, as they were in Northern Europe, they would be found in archaeological contexts. In Portugal and Spain, people preferred to consume their food in ceramic objects, thus it is possible that this cargo could have been destined to be used onboard ships, where pewter plates are more frequent. As for the brass objects, their value and their absence from shipwrecks may indicate other uses. One should not forget that brass objects in the mid-sixteenth century were still used on the coasts of Africa to trade for other commodities. The value of these objects suggests that the wreck of this ship was a huge economical loss.

The value of this ship is enormous in terms of understanding the relational value of the contacts between Northern Europe and the Iberian Peninsula through artifacts. This vessel reveals how people and commodities from different origins interacted in the creation of economic and cultural value. The presence of such pewter objects made in Northern Europe on board an Iberian ship, intended to be used in Iberian domestic environments or sent to be traded by other commodities, reveals a network of relations between people and objects. Ships were the main actors in this relation.

4 Belinho 1 Hull Remains

Both the quantity and the quality of the timber washed ashore, all disconnected, justified their preliminary study, which was carried out in June 2014 by a team from the Centro de História de Além Mar (CHAM) - Social and Human Sciences of the NOVA University of Lisbon (Bettencourt et al. 2015).

In November 2014, at the invitation of the City Council of Esposende, Alexandre Monteiro, from the IAP of the same University, and Filipe Castro, from TAMU, went to Esposende to evaluate the situation and plan a future investigation. A comprehensive study of the timbers was carried out in August of 2015, by a multidisciplinary team of researchers, technicians, students, and volunteers, belonging to and/or framed by various academic institutions. Working within the scope of the ForSEADiscovery Project (EU Marie Curie Grant PITN-2013 GA 607545), and under the direction of Rosa Varela Gomes (IAP / FCSH-UNL) and Filipe Castro (TAMU), the team, which included the grant principal investigators Ana Crespo and Nigel Nayling, carried out a holistic investigation of the artifact collection, with a view to elaborating monographic studies of the several collections (Gomes 2015). The ship timbers were registered and analyzed, to determine the tree species to which they belonged and their age and function in the ship's architecture. Preventive conservation actions were carried out, developed by qualified technicians. A complete catalog of the timbers was also collected and shared online (at Academia.edu). The timber record was carried out with the help of a FARO-Arm, owned by the University of Wales Trinity Saint David together with the completion of the catalog and detailed photographic record (Martins 2015a). The catalog was elaborated by direct observation of each of the individual timbers, and scale drawings of the most important timbers were developed, together with an extensive photographic coverage(Castro et al. 2015).

4.1 Timber Recording

As already mentioned, given the relevance of the Belinho 1 artifact and timber collections, the City Council of Esposende invited a team of maritime archaeology and wood sciences experts from the Marie Curie project ForSEAdiscovery to continue CHAM's preliminary study. Work started in the summer of 2015. The evaluation of the Belinho 1 timber assemblage was carried out with the following four main objectives in mind (Martins 2015b):

1. To establish a date and provenance for the ship and its cargo.
2. To reconstruct the parent trees from the archaeological evidence, in order to try to understand timber growth patterns and ranges of shapes preferred by shipbuilders.
3. To develop dendrological studies on the Belinho 1 timbers (wood anatomy and dendrochronology).
4. To develop a plausible three-dimensional digital ship reconstruction based on timber shapes and other archaeological evidence.

The project was designed in accordance with Historic England's guidance on project design (Historic England) MoRPHE and the Direção Geral do Património Cultural (DGPC) archaeology code of practice. The participation of a professional shipbuilder, Mr. António José Carmo, proved invaluable and was determinant to a fast interpretation of the timber analyzed. The methodology maximized the team efficiency, given the short time available for fieldwork.

Multiple workstations were established in the area provided by the municipality to store, conserve and record the shipwreck remains. Timbers were stored in specially designed tanks. Archaeologists and wood scientists implemented a set of parallel activities to record and interpret both timbers and artifacts. The timbers were tagged, separated by function, and recorded. The recording was carried out in the following three separate ways:

1. Morphological analysis: a fiche was filled for each timber and its conversion and special characteristics were noted.
2. Woodgrain: a FARO-Arm was used to record the most prominent grain patterns apparent of the timber surface, and digital photography to create 3D meshes of the timber surfaces with *PhotoScan*software.
3. Construction features: the shape, measurements, scarves, fastening patterns, and caulking solutions were manually recorded at a 1:10 scale, photographed, and described in individual fiches.

This methodology allowed different teams of researchers to rotate the timbers and work full time. The comprehensive documentation and recording process of individual timbers entailed unique labeling and the use of timber recording sheets (TRS) (Nayling and Jones 2014, p. 243); traditional recording techniques (Marsden 1978; McKee 1978; Tremain 1978); three-dimensional meshes (Jones et al. 2013); computer vision photogrammetry (Yamafune et al. 2017)and the collection of timber cross-section samples by hand-sawing. This workflow resulted in the following:

1. The recording of 11 key structural hull timbers with a FARO-Arm in a format adapted from the manual produced by Toby Jones (2015)—seven Y-frames (BEL01-001W, BEL01-032W, BEL01-036,037W, BEL01-039W, BEL01-040W, BEL01-043W) keel (BEL01-071W), mast step (BEL01-051W), stern knee (BEL01-072W), sternpost (BEL01-073W), and one-floor timber (BEL01-003W).
2. All the 80 timbers that composed the collection were photographed and recorded using direct measurements, computer vision photogrammetry, and hand sketches.
3. Twelve oak samples were collected from timbers displaying more than 50 rings.

Post-recording laboratory analysis undertaken by ForSEADiscovery Project researchers led to the development of a dendrochronological report (Domínguez-Delmás et al. 2016), a detailed catalog of the timber assemblage (Castro et al. 2015), and the editing and printout of the 11 individual timber's 3D digital models, essential to develop advanced studies on tree and ship reconstruction of the Belinho 1 (Martins 2015b).

4.2 Preliminary Analysis of the Timbers

All 80 pieces of timber were found disarticulated and presented vestiges of the dynamic process that dismantling the structure to which they belonged. All these pieces are eroded and broken, with the exception of the stern heel, which is almost intact. Their typology can be included in the early modern Iberian Atlantic shipbuilding tradition, even though they present some aspects not previously observed, namely with regard to the caulking and the protection of the outer surface of the planking.

All timbers were stored in tanks built by the Esposende municipality and divided into groups, which encompassed elements of the longitudinal structure, elements of the transversal structure, planking elements, and non-diagnostic elements.

The timbers were also analyzed from the point of view of the morphology of the trees from which they were cut, and from the point of view of the ship structure, in search of clues to identify the place and the period in which this ship was constructed. The timber morphology report is the subject of Miguel Martins' doctoral thesis, under the guidance of Nigel Nayling at the University of Wales Trinity Saint David.

The first group consisted of timbers from the longitudinal structure and encompassed portions of the keel (BEL01-071W), sternpost (BEL01-073W), stern knee (BEL01-073W), and mast step (BEL01-051W).

The keel segment preserved was rabbeted (around 8.5 cm), measured 879 cm in length and its section was 22–24 cm sided and 19 cm molded. There were no signs of scarves on either end of the keel segment. Twelve 2.7 cm circular bolt holes were preserved along with the timber length, connecting some floor timbers to the keel, spaced around 70 cm on average, if we exclude the distance between bolts 5 and 6, which was 115 cm. The bolt heads, with diameters around 5.5–6 cm, were lodged in countersunk holes 6-7 cm in diameter, and 2.5 cm deep. Marks of 1.1 cm square iron nails, fastening the garboards to the keel, were preserved along the rabbets and spaced 70 cm on average.

The fasteners' pattern on the planking suggested a room and space around 35 cm and indicated that the keelson was bolted to this portion of the keel through every other floor timber, except between bolts five and six, where there were probably two-floor timbers between bolts.

The *sternpost segment* was preserved along 290 cm, and its section was 20 cm sided and 21 cm molded. Three 2.7 cm bolt holes were preserved, spaced 70 cm and 53 cm, which correspond to the spacing of the bolt holes preserved on the stern knee (*coral*). The deep rabbets (31.4 cm deep) presented 1.1 cm square nail holes and 2.5 cm preserved treenails, which fastened the hood ends of the hull planks to the sternpost. These fastening holes allowed the re-positioning of seven hull planks, which had washed ashore separately. The after face of the stern post preserved nail marks that suggest that the sternpost was covered with sheathing, and a protruding tenon with two diagonal nail holes the function of which is not yet clear.

A *stern knee* washed ashore as well, 281 cm long and 20 cm high. Its molded dimension varied between 12.3 cm and 8.7 cm and its sided dimension was 20 cm. Four iron bolts indicate that it was fastened to the keel although the spacing of these bolt holes does not correspond with those found on the surviving fragment of the keel. In contrast, three bolt holes on the upper part of the stern knee match those on the sternpost. Again, two or three 11 mm square nail holes, and two 25 mm treenail remains indicated the fastening pattern of the hull planking to the stern heel side faces.

The remains of a *mast step* bear signs of long exposure to the actions of marine life and were heavily eroded. It is an expanded portion of the keelson, 197 cm long, 45 cm sided, and 30 cm molded. The step mortise is 86 cm in length, 18 cm sided, and 10 cm deep. Two-bolt holes allow a tentative positioning of this portion of the keelson between the seventh and eighth bolt holes of the keel. The mast step is notched to fit over the frames.

The second group of timbers found at the Belinho 1 site—the transversal structure—included seven Y-frames (*picas*), five-floor timbers, three frame fragments that appear to be the lower extremities of first futtocks, two timbers that were tentatively identified as fragments of deck knees, and a broken frame fragment.

The central framing timbers presented square sections around 18 cm sided and molded, and the same pattern of nails and treenails for the fastening of the hull planking. They showed central trapezoidal limber holes positioned slightly to the side of the keel axis, and some had dovetail joints in the preserved extremities, in the area overlapping with the futtocks. The floor/futtock fastening pattern seems to have been two treenails and two iron nails.

Floor timber BEL01-045W did not have an apparent dovetail scarf on its preserved arm but showed a step on the face opposite to the futtock, where a nail was inserted, in a manner similar to those found on the Highbourne Cay shipwreck (Smith et al. 1985; Oertling 1989; and see Chapter 7, Vol. 2).

Floor timber fragment BEL01-041W presented a foot with a central limber hole and only one treenail mark, on its foreword and after faces. One of its arms seems to have been around 30 cm long, suggesting that this timber may have been a reinforcement placed between the inner extremities of two first futtocks, reinforcing the floor timber in the keel area.

Floor timber BEL01-042W presents similar features to the timber described above. The maximum length surviving has 321 cm, and its section was 17 cm sided and 18 cm molded. On one of the sides, this timber has a dovetail scarf measuring 23 cm on the top and 28 cm on base. Evidence shows that at least one nail was inserted on the futtock through is the step. The floor timber also possesses an inscription “II,” which probably indicates its location on the framing system.

The futtock extremities preserved varied in length, mostly near 1 m, and presented sections 16–18 cm sided and molded. Some of the futtocks showed dovetail scarves with a pattern of two or three nails and two or three treenails in the floor/futtock connection.

The two purported deck knees are eroded pieces with fastening patterns and notches that suggest this function, but so far it is not possible to definitely identify them as such.

The third group of timbers washed ashore at Belinho—the stern planking and other longitudinal timbers—included a portion of a waterway, three fragments of port side hull planks with their aft hoods preserved, four fragments of starboard hull planks with their aft hoods preserved, and five plank fragments difficult to position at this stage.

Planks BEL01-053W, BEL01-056W, BEL01-060W, and BEL01-059W angles, fastening holes, and dimensions match the marks and angles on the starboard side of the sternpost. Similarly, planks BEL01-055W, BEL01-054W, and BEL01-057W match port side angles and fasteners' marks of the sternpost.

A curious feature observed in these hull planks is that they were carved with triangular notches 5–7 mm deep, and grooved on their outer surfaces, coated with a resinous substance, and sheathed with either lead or sacrificial wood, although no traces of lead were picked up in several XRF analyses performed on coating samples.

Has expected, the planking conversion type presents evidence of tangential conversion, although at this time it is not possible to identify which tools were used for the process. The level of erosion affected the timbers' surfaces and made it difficult to identify tool marks, although some carpentry marks, such as the number "II" on floor timber BEL01-042W.

The group of the 12 best-preserved hull planking timbers was cut from oak trees bearing a maximum of 128 tree rings and a minimum of 36 annual rings. One of the eroded timber fragments from this group (BEL01-061W) was sampled for dendrochronological analysis. It was not possible to identify the *Quercus* sub-species at the present stage of the project. Planks BEL01-053W, BEL01-056W, BEL01-060W, BEL01-059W, BEL01-055W, BEL01-054W, and BEL01-057W, already mentioned above, do not show evidence of large knots, suggesting that they were cut from straight stem trees.

The fourth group of timbers—plank fragments—consisted of 27 small fragments of planks, impossible to place in any particular position in the hull at this stage of the project.

A fifth group consisted of 11 small fragments of wood from unidentified timbers, also impossible to a position at this stage of the project (Castro et al. 2015).

4.3 Ship Dimensions and Characteristics

The collection of timbers described above presented geometric characteristics indicating that they belonged to the area from amidships to the stern (Fig. 5.3). They also suggest that the flat of the floor timber amidships—the measure of the horizontal part of the base of the master frame—measured around 2.70 m. Considering the characteristics of the merchant ships of this time, this measure suggests a vessel

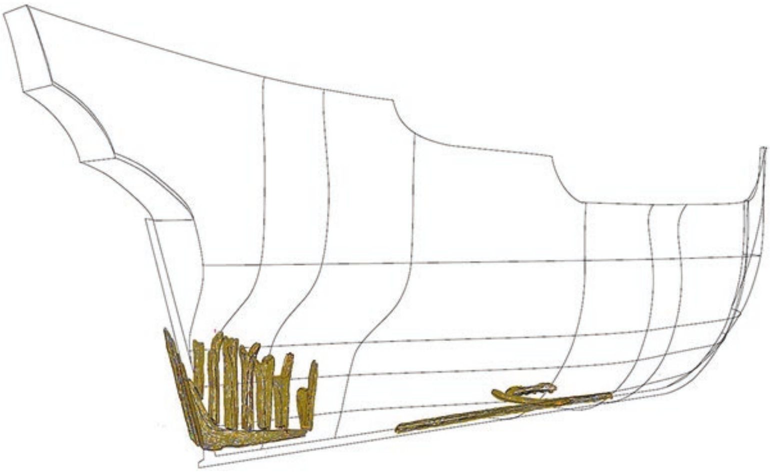

Fig. 5.3 Tentative reconstruction of the ship's structure (Miguel Martins)

Table 5.1 Main timber dimensions from Belinho 1 ship

Timber	Sided	Molded	Preserved
Keel	22–24 cm	19 cm	879 cm
Sternpost	22,24 cm	19 cm	290 cm
Stern heel	18 cm	15–56 cm	281 cm
Floor timbers	15–18 cm	18 cm	282–321 cm
Y-frames	21–26,5 cm	18–23 cm	140–223 cm
Futtocks	16–18 cm	16–19,5 cm	102–112 cm
Knees	21–22 cm	20–23 cm	134–153 cm
Waterway	16 cm	10 cm	396 cm
Hull planking	9–44 cm	6–7 cm	153–332 cm

with a beam two to three times that value (5.4–8.1 m), a keel more or less twice the value of the beam (10, 8–16.2 m), and a length overall of about 16.2–24.3 m.

Although the dimensions inferred indicate a small vessel with about 50 to 100 tons, the sections of the transversal structure suggest a larger vessel. The keel section, the frames, the room, and space—the distance between the frames—and the planking thickness are closer to the averages observed on *San Diego* (1600) or Emanuel Point I (1559) vessels, whose lengths were closer to 30 m. The measures indicated here are preliminary estimates. Table 5.1 indicates the timber measurements recorded in 2015 by the ForSEAdiscoveryteam (Castro et al. 2015).

The central floor timbers and the futtock fragments present vestiges of dovetail joints, a construction trait that is typical of the Atlantic construction tradition of this period, with archaeological parallels in both Iberian and northern European vessels. The fastening pattern of the planks to the frames, with iron nails and treenails, has parallels in the northern region of the Iberian Peninsula.

The existence of a stern heel probably not associated with a stern knee—a curved piece that connected the keel and the sternpost on some Iberian ships—is not exclusive of the Iberian Peninsula shipbuilding tradition. The geometry of the Belinho 1 stern knee, with the posterior corner cut at an angle, has archaeological parallels in the Basque ship *San Juan*, lost in 1565 in Newfoundland, and the early seventeenth-century Fuxa shipwreck, lost in Cuba and of unknown origin. In most ships believed to be Iberian the stern heel and knee have a contact surface rounded, without angles. The angle of the sternpost with the keel is 75.6°, a value consistent with the historical and archaeological parallels considered (Table 5.2). Spanish ships also seem to have lower sternpost angles than the Portuguese ones, even though the sample of values we have is rather small.

The protection of the hull planking is unique, with no published archaeological parallels. The boards were prepared on the outer face with triangular incisions and horizontal or sub-horizontal carved grooves, following the wood grain, 5–7 mm deep, and coated with a fatty substance whose analysis is still pending. A significant number of small nail marks indicates the existence of an outer sheathing, with sacrificial wood planks or with lead straps. The irregularity of the sheathing nails (or tacks) suggests that the hull was protected with lead sheathing. Moreover, half 100 sheets of lead, similar to those found in the Angra D shipwreck—believed to be a Spanish ship of the late sixteenth or early seventeenth century (Monteiro 1999)—were found in the area of the shipwreck. Both the inner and outer surfaces of the planks had irregular saw marks, suggesting they had been sawn by hand, as well as adze marks—as it is characteristic of ships of the sixteenth and seventeenth centuries.

The mast step is an extension of the keelson, wider and notched over the floor timbers. This shape is typical of both Iberian and North European vessels.

Digital models of each of the selected timbers were used to produce working files that better represented the morphology and the final shape of each of the 11 key structural hull timbers. The original 3D files were first edited in *Rhinoceros* to remove irrelevant lines and ensure that all lines were associated with the correct layers, both in terms of the faces represented and the attributes assigned. The edited

Table 5.2 Sternpost angles to the horizontal

Ship	Country	Date	Angle
San Diego	Spain	1600	60°
Western ledge reef	Spain	ca. 1600	63–65°
Nau de Garcia de Palácio	Spain	1587	64–65°
San Esteban	Spain	1554	65°
Nau de Escalante Mendoza	Spain	1575	71°
San Juan	Spain	1565	72–73°
Nau de M. Fernandez	Portugal	1616	74°
Belinho 1	?	1525–1580?	75,6°
Nau de F. Oliveira	Portugal	ca. 1580	77–78°
Navio do Corpo Santo	Portugal?	ca. 1400	78°

files provided clearer 3D models of the 11 individual timbers and were used as the basis for another series of new files.

In order to produce 2D traditional drawings, each face was projected onto an orthogonal plane. This task produced a set of 2D orthographic projections of each timber face, complemented with cross-sections (Fig. 5.4).

The drawings developed were produced by merging the 3D models with the photogrammetry data, and adding the information collected through inspection on the timber recordings sheets, and fieldwork notes. This task aimed at highlighting construction features in each timber, namely the fastening patterns, scarves, caulking arrangements, sections, and shapes.

Although none of the then 80 timbers washed ashore in connection with any other timber, the angles of some of the outer planks' hoods and the position of some of the fasteners allowed the matching of 19 individual timbers, forming a portion of the ship's runs (Castro et al. 2015).

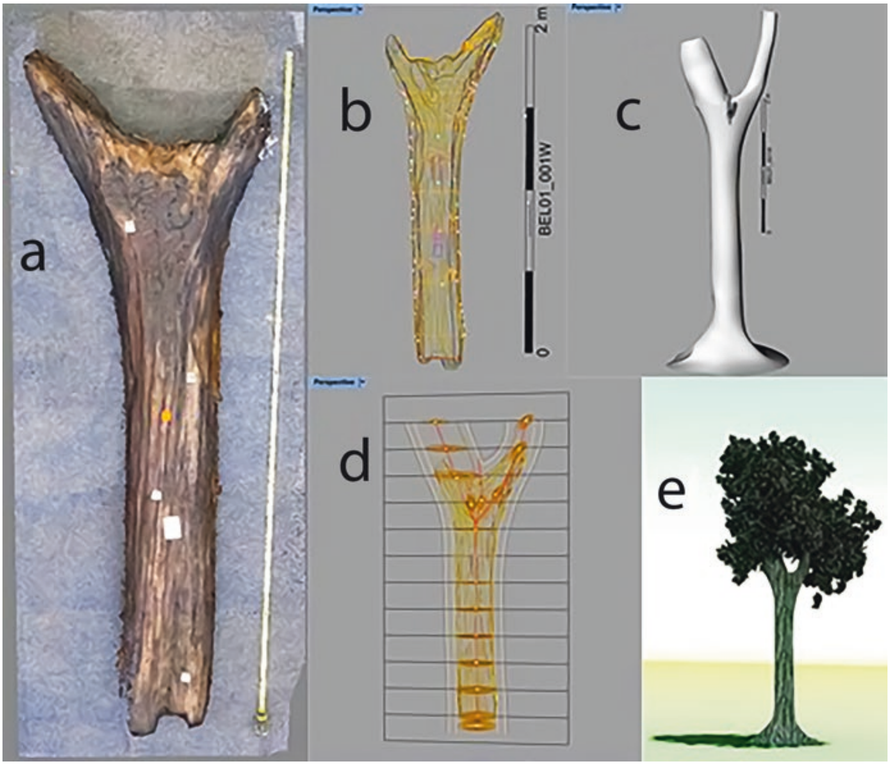

Fig. 5.4 Timber BEL01-001W Y-frame; (**a**) photogrammetric model, (**b**) 3D drawing produced using a 3D digitizer arm, (**c**) 3D line drawing of tree features extrapolated, (**d**) 3D surface model of the parent tree, (**e**) 3D rendered reconstruction of the parent tree. (3D digital drawings by Adolfo Miguel Martins and photogrammetry by Nigel Nayling)

The fourth type of drawing was produced from the edited files and used in the tree reconstruction process. On these files, the layers containing the wood conversion were hidden and the natural wood features were highlighted, following a process that will be detailed in the section on tree reconstruction below. In this way, the drawings obtained reproduce a set of diagnostic features with precision, revealing growth patterns, natural edges, branches, and knots.

4.4 Sample Collection, Wood Identification, and Dendrochronological Results

After completion of the recording process, a selection of the timbers was sampled by either coring or sawing, yielding a total of 15 samples. Sampling was performed with care, to minimize its impact on the timbers. Increment borers were used to sample timbers that possessed good dendrochronological potential, namely substantial number of tree rings and presence of sapwood, but which would lose integrity if sampled with a saw. The remaining elements were sampled by sawing their ends, thus mitigating the impact on the integrity of the timbers. Wood samples were sent to different laboratories within the ForSEAdiscovery network where they undertook a variety of analyses, particularly for dating, wood anatomy studies, and geochemical analysis purposes (see Chapter 1, Vol. 2 for further details).

The visual inspection of the samples allowed the identification of 12 of them as deciduous oak (*Quercus* subg. *Quercus*). Two other samples correspond to conifer species, although the observation of anatomical features with a microscope in the radial section has not led to the identification of the timber species. Finally, one sample from timber of uncertain origin—possibly not part of the ship structure—was found to belong to a tropical species and was excluded from further analysis.

The comparison of all the tree-ring series with European reference chronologies and oak chronologies from the north of Spain failed (for the moment) to produce statistically sound results. Therefore, all samples remain for now undated, and the provenance of the wood remains unknown.

4.5 Tree Reconstruction

As already mentioned in a previous paper of which parts are reproduced here, the Belinho 1 timber assemblage suffered significant levels of erosion, which increased the difficulty of the recording process (Almeida et al. 2020; Martins et al. 2020b). Despite this, the timbers analyzed offered relevant data for advanced dendrological studies. The seven Y-frames, a complete floor timber, the stern knee, the sternpost, a portion of the keel, and the fragment of the keelson (mast step) were selected for careful recording using digital techniques due to their potential to provide relevant data for tree reconstruction.

Evidence of knots, cracks, and growth patterns was used to plot the location of the timber pith along the full length of each timber. The tree rings visible at end of the Y-frames clearly indicated the points where the tree stem split into two or more branches. The grain lines on the floor timbers were useful for the identification of the curvature of the parent tree.

The timber recording methods employed, both manual and with a FARO-Arm, reproduced with precision the wood features that led to the tentative tree reconstructions. The 3D digital models produced followed specific recording protocols, which enabled the identification of exact angles of curvature, and potentially diameter of the parent trees, in comparison with the shape and size of the selected individual timbers. This method proved to be effective and allowed us to identify the particularities of the parent tree of each timber, namely ring widths, grain curvature on the main stem, as well as position, density, and angles of branches.

As mentioned above, once the 3D digital models were edited and re-inspected, it was possible to hide the layers related to the work performed by the carpenters with *Rhinoceros* software. The resulting models represent only the wood features, which give a clear view of the wood anatomy on each timber surface. The grain lines and the inclination of the knots are essential to identify the direction of the tree (roots and canopy). Once the growth direction is identified, the next step is to find the pith location in the stem and branches, which was possible in the case of the stern knee and Y-frames. The maximum width can be defined by the pith and the preserved waney edges on the timber surface. The ring-width and natural heartwood edges can also provide additional information. After achieving the maximum width on each surface and identifying the growth direction, it is possible to recognize the shape of the tree and some of its morphological characteristics. Sapwood was only observed on timber BEL01-001W, which made it impossible to identify the maximum diameter of each timber. Either bark and sapwood was removed during woodworking, in keeping with the advice given in broadly contemporary shipbuilding treatises, such as Oliveira'sLiuro da Fabrica das Naos*, or Lavanha's*LivroPrimeiro da Architectura Naval*, or it was lost, eroded after the shipwreck.

The Belinho 1 ship timbers were tangentially cut from the parent trees and then shaped using a variety of tools to meet the required shape.

The Y-frames presented shapes consistent with the transverse and longitudinal angles of the hull. The Y-frames' feet were cut at angles that fit over the stern knee where they stood, and their height formed a plausible shape of the transition between the ship's runs and the wider portion of the upper hull in that area. The progression of the angles of branches of each of the Y-frames positioned on the inboard face of the stern knee showed a consistent pattern and formed a smooth, fair, and thus plausible shape of that part of the hull:

- Y-frame BEL01-037W angle of the branches is 3°, the length of the stem 99.2 cm, abundant knots along the stem.

- Y-frame BEL01-036W angle of the branches is 8°, the length of the stem 148.3 cm, not having knots along the stem.
- Y-frame BEL01-039W angle of the branches is 12°, the length of the stem 145.7 cm, abundant knots along the stem.
- Y-frame BEL01-001W angle of the branches is 22°, the length of the stem 149.2 cm, not having knots along the stem.
- Y-frame BEL01-040W angle of the branches is 24°, the length of the stem 127.1 cm, abundant knots along the stem.
- Y-frame BEL01-043W angle of the branches is 21° but reduces the length of the stem to 83.9 cm, abundant knots along the stem.
- Y-frame BEL01-032W angle of the branches is 15°, the length of the stem 184.6 cm, not having knots along the stem.

The longitudinal structural timbers revealed the following features:

- To shape the stern knee carpenters needed a tree with a larger stem and branches having an angle of about 105° between each (in comparison to the timbers previously mentioned);
- To obtain the keel carpenters needed a long tree with a minimum of 900 cm in length and 22.3 cm in width. This timber also presents a larger branch on its inboard face. Many other relatively small size branches can be observed along each surface of the keel full extension.

Evidence has also shown that to build the Belinho 1 ship carpenters needed at least the following four types of trees:

- Y-frames—straight stemmed oak trees ending with at least two branches in the canopy-forming symmetrical angles from vertical;
- Floor timber and futtocks—long stem or branches having a smooth curvature;
- Stern knee—large stem and branches with an angle closer to 105°;
- Keel—long straight stem having a minimum of 900 cm in length.

At this stage, this study allowed the following conclusions:
BEL01-001W (Y-frame):

- Minimum diameter of the stem is 74 cm, minimum diameter of the port side branch is 18 cm, angle of the stem to the branch is 15°, the minimum diameter of the starboard side branch is 21.4 cm, the angle stem to the branch is 156°, and the maximum length of the stem with the absence of knots is 149 cm;
- The absence of knots along the main stem;
- Specific V-shape of the canopy;
- The width of the stem is consistent with the other timbers in the ship's stern;
- The pith, growth pattern, and the split of the stem into two branches provided the shape required for ship construction;
- The growth rate (i.e., average ring-width) is consistent with higher levels of moisture (precipitation/groundwater levels);
- The sapwood was removed to shape the timber, but the heartwood seems to preserve its maximum extent (some traces of sapwood).

BEL01-003W (floor timber):

- Clear growth orientation of the timber (crown/stem).
- The abundance of knots at one end.
- The curvature of the timber is consistent with the natural curvature of the tree.
- Fast-growing timber suggests a landscape abundant in water and minerals.
- The grain at the lower end of the timber suggests the existent of forest practice to encourage the growth of multiple branches (pruning/pollarding).
- At the bottom of the timber, the growth pattern is consistent with forest management techniques.

The process of tree reconstruction involves a complex data analysis in which every wood feature needs to be carefully inspected. In this particular case, it is a still ongoing study, undertaken within author Miguel Martins' doctoral studies as a Marie Curie—ForSEADiscovery Project fellow.

Timber analysis requires that archaeologists acquire experience in both shipbuilding characterization and dendrology. The recording process should aim at acquiring compounded information related to shipbuilding and wood anatomy. This study is a contribution to the development of a methodology that will hopefully become mainstream in nautical archaeology within a few years. The recording protocols we will develop in the incoming years will allow for new forms of 3D recording, manual samplings, visual observation, and any other methods available, such as X-rays or magnetic resonance. The 3D digitizer arm proved to be an extremely effective tool, mostly when compounded with *Rhinoceros* software. Budget and fieldwork time constrains most probably dictate that only a selection of timbers will be digitally recording and analyzed (as was the case in the Belinho 1 Project).

We opted to convert the 1:10 scale drawings into 3D digital representations later, in order to manipulate the timbers and try to match them against an hypothetical model of the hull, developed from the only diagnostic measurements we could obtain from the archaeological data: the flat of the floor timber near amidships, and the probable height of the ship's runs. Our reconstruction is hypothetical and should be looked upon as a preliminary attempt at making sense of the timbers that washed ashore at Belinho in 2014 and 2015.

5 Conservation

In the first phase, the timbers were wrapped in plastic film and then immersed in a tank with excellent conditions for the storage of wet and fragile wood pieces. The pewter plates received initial palliative treatment and were packed in accordance with diameter and typology for further treatment and the concretions were x-rayed and stored under appropriate conditions (Almeida et al. 2020; Martins et al. 2020b).

Then meetings were held with conservation technicians from the Laboratory of the Archaeology Office of neighboring Vila do Conde municipality, as well as CNANS, whose input helped the development of the conservation plan. Protocols were established between Esposende, through its Cultural Heritage Service, and the Laboratory of Conservation and Restoration of the Archaeology Office of Vila do Conde, and the Laboratory of the Archaeological Museum D. Diogo de Sousa, in nearby Braga, to establish a collaboration that provided the best possible conservation care, decision-making, and the implementation of good practice rules in all required conservation work of waterlogged artifacts.

In 2015 Christopher Dostal, a conservator from Texas A&M University integrated the team, promoting the orientation of further work based on his experience. Under his orientation, X-Rays of some of the composite materials took place, as well as the analysis of the majority of pewter plates that reveal marks presences.

Since 2018, the CME hired Elsa Teixeira, a conservative restorer who, assisted by the teams of conservation from the institutions mentioned previously, guarantees the conservation work. Under her orientation, new X-Rays have been carried out revealing, for instance, the shape of the sward's scabbard. All the artifacts were stored in the premises of the Municipal Council of Esposende and properly conditioned, after receiving the appropriate palliative care. The timbers were wrapped in plastic film and then immersed in a tank with excellent conditions for the storage of wet and fragile wood pieces. The pewter plates received initial palliative treatment and were packed in accordance with diameter and typology for further treatment by electrolysis. The concretions were x-rayed, and the remaining materials were packed and stored under appropriate conditions. The artifacts were filed in a database with a scaled photograph and, where possible, an X-ray of some of the composite materials. A photographic record was also developed, detailing the tasks executed and the recovered artifacts. At this stage of the project, and considering the quantity and diversity of the collection, CME is evaluating various possibilities for the conservation of artifacts by a specialized laboratory.

6 Conclusions

The main conclusions of this study can be summarized along two main lines. The first is that this study setup clearly the need for protocols to standardize the recording of both nautical information (Castro et al. 2018) and that these protocols must include dendrological analysis. The second is that although at this time neither archaeological nor dendrological evidence has shown a strong correlation between the Belinho 1 timber assemblage the shipwreck discovered in the archival research, there is no reason to change our methodology. Dendrochronological evidence has not yet yielded any matches, and the artifact collection doesn't seem consistent with the ship's route.

It is difficult to accurately date this site at such a preliminary stage of the project. Part of the artifacts suggests a first half/mid of the sixteenth-century date, while the armament seems to suggest a date nearer the middle of the sixteenth century. Old guns, sometimes cast more than 50 years before the sinking, have been found in both naval and trading vessels, however, and only a finer analysis of the artifact collection will allow a better dating of this shipwreck.

The octagonal bronze demi-culverins from Belinho 1 are similar to the one found in the Oranjemund shipwreck, tentatively identified as the 1533 *Bom Jesus* ship, lost on the coast of today's Namibia on its voyage to India. Other materials found on the Oranjemund site are similar as well, such as the porringers, the tin plates, and the stone cannon balls (Knabe and Noli 2012). The study of the artifact collection is ongoing, and we expect to see results in 2021.

A shipwreck record in this area was recently found in archives, the ship *Nossa Senhora da Rosa*, lost in 1577 "through Esposende"(Barros 2016, 2020), coming from the Canary Islands to Vila do Conde with a load of wine and pitch. The Belinho 1 shipwreck seems to be larger, however, and its cargo seems to have originated in the North of Europe, thus this will not be considered as an option.

Its possible Iberian construction, presumably from the north coast of Spain, remains a possibility that the ongoing dendrochronological and morphological study of the timber may help clarify.

The studies carried out on the Belinho 1 ship timbers allowed us, however, to conclude that from the 12 samples that underwent dendrochronological research, both framing and planking elements presented fast and slow growth rates, suggesting that there was an unspecific selection of trees in terms of growth types for the construction of this ship. Although in order to draw conclusions relative to the quality of the timber supply we will need to carry out further analysis, this is an important piece of information on the incomplete multidimensional puzzle that every shipwreck presents (see Chapter 1, Vol. 2).

The tree reconstruction attempts carried out on the Y-frame BEL01-001W and floor timber BEL01-003W allowed to characterize their parent trees with a good degree of certainty, yielding information on the forest where the timbers originated from. Straight stems with a low number of knots were sought by shipwrights for their strength and are typical of trees that have grown in high-density stands.

The structural timbers analyzed presented evidence of having been selected in accordance with the wood grain flow orientation to avoid cracking by tension and show that both straight and compass timber—trees and branches—were available in the forests where they were cut.

The sample of deciduous oaks showing variable growth rates and lacking internal cross matches suggests that the wood was sourced from different areas or an extensive area where tree growth was variable. The growth pattern seemed to be consistent with oak trees of about 60 years (average of annual 50 rings plus rings lost by erosion, or removal sapwood and bark). The Y-frames also seem to be consistent in terms of growth pattern, and the floor timber and futtocks present the same correlation within each typology. Equally, the absence of a significant number of knots along the timbers presented evidence of the areas in which the trees were planted. The ring-width average has also demonstrated to which extent trees were supplied with abundant water and minerals (precipitation/groundwater levels).

As already mentioned, given the relatively small number of timbers sampled there is a possibility that some of the analyzed timbers may not be contemporary, corresponding to possible repairs. Again, this piece of information is relevant for the ongoing study of the ship.

Although the nature of the Belinho 1 shipwreck site, located in a high energy area which poses serious risks to diving, has determined the slow pace of this study, mostly commanded by the atmospheric conditions and the natural movement of sediments of the bottom, the information already gathered allows us to emphasize the importance of this site. The ship timbers shape and assemblage techniques are consistent with an Iberian architectural provenance, and even though the tentative chronologies established for the artifacts do not permit a tentative dating within a few decades, it is likely that this ship dates to the second quarter of the sixteenth century, making it a precious testimony to the European shipbuilding techniques of that time.

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Chapter 6
Shipwrecks of the Iberian Tradition in the Bay of Cádiz (Andalucía, Spain)

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Abstract The objective of this work is to analyze through documentary and archaeological sources the shipwrecks of the Iberian tradition in the Bay of Cadiz. It supposes the evidence of the commercial redistribution activities between Europe and America that took place in that area of the south of Spain during modern times, in the course of the *Carrera de Indias*, where ships of Iberian–Atlantic construction played a key role in allowing transoceanic navigation. Nowadays, these historic shipwrecks are part of the Underwater Archaeological Heritage of Andalusia. Its analysis and systematization are the two objectives of the Underwater Archaeology Centre (CAS) of the Institute of Historical Heritage of Andalusia (IAPH), created in 1997 to investigate the Underwater Archaeological and Maritime Cultural Heritage of the Andalusian autonomous community. The research and protection of this heritage has led to the location and scientific study of the two shipwrecks of the Modern Age and Iberian–Atlantic tradition described throughout these pages.

1 Geographical Framework

Together with the Portuguese and the Cantabrian areas, the Gulf of Cádiz is one of the most important geographical spaces in the Iberian Peninsula, with a great maritime projection in modern times (Casado 1991). In its area of influence, there are two subareas of vital importance for the commercial activities that Spain developed

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with overseas territories, in what has been called the *Carrera de Indias*. It covers the fluvio-maritime space of the mouth and channel of the Guadalquivir River, plus the port area of Seville, and the surrounding area. This territory is the object of the present study: the Bay of Cádiz, integrating the towns of Rota, El Puerto de Santa María, Puerto Real, San Fernando, and Cádiz. It is worth noting that the location of this Bay, in the south of the Iberian Peninsula, is in an unmatched geostrategic position as a connection point between continents: Europe with America on a west–east axis, and with the African continent on a north–South axis. The region presents a landscape modeled by anthropic action, the silting caused by the river Guadalete—which has its mouth in the municipality of El Puerto de Santa María—and the sedimentary contribution of the several pipes that pour water into its basin. In this way, the archipelago of the Gadeiras Islands has been transformed, over the centuries, into an optimal harbor for anchoring boats, as evidenced by the commitment made by the different civilizations that settled the area and which is attested by the abundant archaeological remains of underwater provenance.

The Early Modern Era was one of the moments in which there was a notable increase in commercial traffic, with the designation of Cádiz as the main port of the *Carrera de Indias*, where ships of Iberian–Atlantic construction played a key role by allowing transoceanic navigation in much more difficult waters than the Mediterranean ones.

The main characteristics of this Bay include the capacity for shelter and anchorage, loading and unloading, as well as for naval repairs, as evidenced by the intense maritime traffic that this area endured, especially in the eighteenth century (Márquez Carmona 2006; Márquez Carmona et al. 2016; Márquez Carmona 2019; Rodríguez 2017).

2 Historical Context

The incorporation of the new American territories into the Spanish Empire forced the Spanish monarchy to propose a model of exploitation with tight economic and political control, based on a monopoly system, and a large bureaucratic organization. At the same time, it became necessary to build more robust vessels than those used in the Iberian space to withstand the challenges of navigation across the Atlantic. The subsequent trade of the products transported to Spain in the *Carrera de Indias* had a diachronic development from Seville and Cádiz. Through the following pages the existing data on vessels of Iberian–Atlantic tradition—between the sixteenth to the eighteenth centuries—in the Bay of Cádiz will be analyzed, in articulation with the port area these ships have used.

There are various sources that report on the commercial activities that took place in the Bay of Cádiz during modern times. Among them, those of textual, cartographic, or iconographic nature stand out, as well as the archaeological ones.

At the beginning of the *Carrera de Indias,* the role played by experienced pilots and boats from the North of Spain, who already had deep-sea sailing experiences, is noteworthy. For example, in the whale fisheries, as demonstrated by the *San Juan* shipwreck, a Basque whaler sunk in 1565 in Red Bay (Canada), or in the navigations carried out along the African Atlantic space, to the Gulf of Guinea and the Canary Islands. These pilots came to form a union in Cádiz by founding, in the fifteenth century, the "Colegio de PilotosVizcaínos." Its presence is attested by the shipwrecks of Biscayan ships in the sixteenth century, which have been registered in documentary sources available in the database that the CAS has for the management of historical shipwrecks (DOCUSUB). The monopoly system was structured at first from the river port of Seville, but for different reasons, such as the ship's increased tonnage and the shallows in certain sections of the Guadalquivir, which the galleons crossed with difficulty already in the sixteenth century, the system was transferred to the Bay of Cádiz.

The feudal control of this space, where there were several population centers, made the Catholic Monarchs aware that they did not have a royal harbor in the area. For this reason, in 1483, the foundation of a little city, the "Real Villa de Puerto Real" was proposed. Officially there is evidence that, since 1680, the fleets of the *Carrera de Indias* were already leaving from the Bay of Cádiz, although the controlling organizations—*Casa de Contratación* and *Consulado de Cargadores*—did not move to this city until 1717. The distinction of Cádiz as the only Spanish harbor enabled for trade with America remained in place until 1778 when it was terminated by King Carlos III. This monopoly provided spectacular financial growth to Cádiz and the other neighboring port populations, and that generated a consequent demographic and urban growth, highlighting, in this sense, the palaces built by national and foreign merchants with their characteristic lookout towers to see the arrival of the ships. At the same time Cádiz, both for its strategic position and its wealth, became a destination coveted by pirates and privateers, justifying, among others, the assaults of the privateer Drake (1587) and the Duke of Essex (1596), the eternal English rivals. To facilitate the harbor's defense, it was necessary to develop a system of fortifications that turned the city, with its walls, castles, and bastions, into one of the most impregnable harbors in the world. These constructions have become a rich Historical Heritage of a defensive nature.

The investigation of the maritime activity that took place in this western area of the Andalusian coast can be carried out through the historical documentation preserved, among others, in the General Archive of the Indies, where all the documentation generated by the institutions that controlled the overseas territories is protected, both in its Sevillian and Cádiz centers(Garcia-Baquero Gonzalez 1976; Chaunu and Chaunu 1977; Flores 1982; Pérez-Mallaína Bueno 2015). The research of the maritime history of the region allows us to register and sometimes locate shipwrecks in the documents analyzed (see Chapter 3, Vol. 1). The analysis and systematization of these data are one of the missions of the Underwater Archaeology Centre (CAS) of the Institute of Historical Heritage of Andalusia (IAPH), created in 1997 to investigate the Underwater Archaeological, and Maritime Cultural Heritage of the Andalusian autonomous community. This analysis is framed within the Underwater Archaeological Charter Project (García Rivera and Alzaga 2008), a basic instrument on which the administration relies when defining specific research and protection strategies (Alzaga and García Rivera 2014).

While analyzing the maritime activity of the *Carrera de Indias*, we note that a significant percentage of ships failed in their arrival at the destination port, in both directions of the voyage. The route carried certain risks: enemy attacks, inclement weather—notable hurricanes in the Caribbean area—, or technical failures. On many occasions, the danger of shipwreck occurred practically at the doorstep of the port of destiny: enemy navies and privateer ships presented a serious danger, stationed along the Portuguese coast, at Huelva, or between Sanlúcar and the Rota coast. Collision with the rocky shallows of the Bay of Cádiz was another cause of problems, sometimes pushed by the strong east and west winds that are frequent at the Bay of Cádiz. Today these historic shipwrecks are part of the Underwater Archaeological Heritage of Andalusia. The CAS of the IAPH carries out its study, for this period, relying on both underwater archaeological remains and documentary sources preserved and guarded in archives, libraries, and newspaper archives. Thus, since 2004 and within the Underwater Archaeological Heritage and Transformation of the Physical Environment Project in the Gulf of Cádiz, work has been developed to identify the archival sources that provide information on the Underwater Cultural Heritage of Andalusia. These studies have, among one of their objectives, the power to position the shipwrecks of which there is documentary evidence (Alonso Villalobos et al. 2010). All this information has been managed through a digital tool designed for this purpose and called SIGNAUTA, a geographic information system created in 2005, and which is divided into six subsystems, among which is the base DOCUSUB data collection, which contains information on shipwrecks that are recorded through historical documentation (Alonso Villalobos, Carlos; Benítez López, David; Márquez Carmona and Valiente Romero, Antonio; Ramos Miguélez 2007).

In the same way, the CAS of the IAPH has worked extensively on the study of cartographic sources of the Bay of Cádiz, documenting the landscape of this geographical space and the maritime cultural heritage associated with it, from the sixteenth to the early nineteenth centuries. This research has addressed specific aspects such as naval construction, port infrastructures, maritime navigation and signaling systems, the defense system of the coastline, transport infrastructure, the maritime health system, the supply system and use of marine resources, and of course the toponymy and its evolution (Márquez Carmona et al. 2016). In this sense, the Bay of Cádiz'functioning as a common port area must be re-emphasized. There were first and second-order infrastructures that were insufficient, due to their low importance, to manage the high maritime traffic: Trocadero at Puerto Real, the port area of Cádiz, the port area of the Guadalete River in El Puerto de Santa María, and the area of Fadricas and Caño de Sancti Petri, in the Real Isla de León (San Fernando). The areas dedicated to naval construction and repair were located in the area of Puntales, Suazo Bridge (Real Carenero), in the fifteenth to seventeenth centuries, and from the beginning of the eighteenth century (1717) the Arsenal of La Carraca was added, for the construction of military ships with the impetus given to the

Spanish navy by the new royal dynasty, the Bourbons. All this information obtained through the compilation and analysis of documentary sources has provided relevant data on areas of possible archaeological potential. In these, the second phase of work has been carried out, within the Underwater Archaeological Charter Project, consisting of an archaeological intervention, by conducting surveys.

All this has made it possible to acquire important knowledge about the sites and areas of archaeological potential in the Bay of Cádiz, which has made it possible to apply the existing protection figures in heritage legislation. In this way, this space was declared an Archaeological Easement Zone with the name "Underwater Space of the Bay of Cádiz" (BOJA. Order April 20, 2009), and has in turn been inscribed in the General Catalog of Historical Heritage Andalusian as Assets of Cultural Interest (BIC), as an Archaeological Zone with a total of 17 areas (Alzaga and García Rivera 2014). The Law 14/2007 on the Historical Heritage of Andalusia grants both states the following definition: (a) "Archaeological Zones" are those clearly delimited spaces in which the existence of archaeological remains of relevant interest has been verified; and (b) "Archaeological Reserves" are those clearly determined spaces in which the existence of archaeological remains is presumed, and it is considered necessary to adopt precautionary measures.

The importance of the application of this protection status is clear since among the immediate effects of their registration and declaration is the need to have authorization from the competent Ministry in the field of Historical Heritage to make any change or modification that individuals or other public administrations wish to carry out in properties that are the object of registration as a Site of Cultural Interest or in its environment. At the same time, carrying out construction works or any other actions that entail the removal of sediment in archaeological easement areas, must also be notified to the Ministry at least 15 days in advance. These measures represent an important and outstanding advance by guaranteeing the legal protection of this heritage and by producing an advance in its preventive management, especially in the face of the proliferation of legitimate activities, for example, infrastructure works, which affect the marine environment and that entail, in many of the cases, activities such as dredging, foundations, fillings, spills, etc. All these activities produce sediment movements or transformations of the substrate, actions that can cause the total or partial alteration of archaeological remains, or motivate the perceptual distortion on them (Alzaga and García Rivera 2014).

In this sense, the application of these protection statuses has allowed the establishment of archaeological precautions, whenever they are considered necessary, before the execution of infrastructure and other works. These cautions have also undergone an important evolution from the first archaeological dredging control—carried out in Cádiz in 1982 (Martí and Gallardo 1997)—to the present, in such a way that it has evolved from the mere recovery of archaeological remains to a joint work carried out between the different administrations involved, to try to minimize the impact of these works on the underwater archaeological heritage.

3 Ibero–Atlantic Tradition Shipwrecks in the Bay of Cádiz

The Bay of Cádiz is widely represented in rutters and on nautical charts, both national and foreign—especially English, French, and Dutch—which are fundamental documentary sources to reconstruct the reality of the region's maritime cultural landscape. Documents show that the most protected part of the Bay—the internal basin—known as Ensenada de Puntales, which currently suffers from a serious silting problem, was the place, together with the Arillo River, where the fleets were prepared for the voyage at an early date. The directions and nautical charts have also been very useful to position the shipwrecks for which there is documental evidence, presented below in a synthetic and quantitative way, with the intention of trying to discern the shipwrecks of the Iberian–Atlantic tradition that is the objective of this article.

After analyzing the existing information in the database that manages historical shipwrecks according to the available documental evidence, it can be seen that of the 2000 records it currently contains, 559 correspond to shipwrecks in the area of the Bay of Cádiz for Modern and Contemporary times. From the figures provided, it can be concluded that it is one of the areas with the highest concentration of subsidence of which there is documentary evidence in all of Andalusia. If we make a limitation between the fifteenth and eighteenth centuries, a total of 310 records of shipwrecks are obtained, and of 224 shipwrecks for the nineteenth century, which reflects that maritime traffic continued to rise after the Free Trade Decree. However, it should be noted that this last period has been further investigated through a documental collection of the historical press. Obtaining information on ships of Ibero–Atlantic construction has been possible by interrogating the system through the nationality and chronology fields, data that have been reflected in the following table (Table 6.1), where shipwrecks of other nationalities are also included, in order to be able to carry out a comparative analysis.

In the same way, the following table (Table 6.2) has analyzed the typology of the shipwrecks that occurred in the study area from the fifteenth to the eighteenth

Table 6.1 Number of shipwrecks listed by nationality and chronology

Nationality	XV	XVI	XVII	XVIII
Spanish	3	51	28	12
Portuguese		2	1	
French		1	9	4
English		1	3	1
Genoese		1	2	
Dutch	1		2	
Swedish				2
From Hamburg			1	
From Ragusa				1
Without nationality	3	54	98	29
Total	7	110	144	49

Table 6.2 Number of Spanish and Portuguese shipwrecks listed by typology and chronology

Typology	XV	XVI	XVII	XVIII
Ship		3S-1P	5 S	4 S
Galleon		5 S	3 S	
Nao	1 S	33 S -1P	8 S	
Carabel	2 S		1 S	
Frigate/Bergantine		1 S	1 S	1 S
Polacra				1 S
Urca		3 S	1 S	
Patache			3 S	
Navetta		1P		
Falu				1 S
Faluce				1 S
Tartan				1 S
Diat				1 S
Without references		4 S	6 S	2 S
TOTAL	3 S	49 S-3P	28 S	12 S

centuries, both of Spanish and Portuguese nationality, although it must be noted that it has only been done with reference to those shipwreck records that have the nationality field filled in, in such a way that that number may be increased in future investigations.

As can be seen in the table, the wrecks of Portuguese ships are barely reflected—only three shipwrecks in the sixteenth century—although the number is increased by four more shipwrecks at the beginning of the nineteenth century: two schooners (*goletas*), a *nao,* and a warship. The ships of Cantabrian origin, named Biscaynes, are present mainly in the sixteenth century, with nine shipwrecks and one in the seventeenth century. Undoubtedly, the increase in shipwrecks of Iberian–Atlantic origin is greater, and of course, it will increase as the historical documentation expands.

The information obtained over the last years of research and of documentary sources must be qualified based on the objective and methodological development of the work carried out in the CAS. As has already been commented, the main objective of the Centre is to generate the largest possible amount of data—textual, cartographic, oral, archaeological, and geophysical information—for the Archaeological Chart, as an instrument of protection. In this sense, the documentary investigation that has been carried out has been limited by the following facts:

- The highest percentage of consulted documentary sources comes from the General Archive of the Indies, so references to ships of other nationalities are scarce.
- The main interest throughout the research carried out has been to collect quantitative data on shipwrecks, specifying as much as possible the area where they occurred, to favor the protection and investigation of this heritage.

- It is considered necessary to carry out more exhaustive and qualitative historical research for each of the shipwrecks located. Reference to named ship types can be imprecise if the documentation consulted does not include it.
- From all these reasons it is concluded that the information collected in the summary tables presented above must be qualified in relation to aspects such as:
- The number of ships of other nationalities will increase when other files are investigated.
- The quantitative predominance of shipwrecks in the seventeenth century is due to the fact that it is the most analyzed historical period.
- The high number of shipwrecks corresponding to the nineteenth century, a total number of 224, is due to the massive research carried out on the historical press, as a source of information.

The archaeological work carried out in the Bay of Cádiz has provided the location and study of various archaeological sites, which can be ascribed, from a chronological point of view, from the Phoenician–Punic era to the present time. Among them, two shipwrecks from the Modern Age, of Ibero–Atlantic tradition, stand out: the so-called "Pecio de los Bajos de San Sebastián" and the Delta I wreck, whose description and analysis will be developed in the following pages.

4 Wreck of "Bajos de San Sebastián"

The wreck "Bajos de San Sebastián" is located in the extreme north-west of Cádiz, in the surroundings of La Caleta, an emblematic landscape formed by an arm of the sea framed by two strings of reefs, that of Santa Catalina-Punta del Nao reef to the north and the San Sebastián reef to the south. This reef continues under the sea to open waters, forming the so-called Punta del Sur. This shipwreck is located on the north cliff of the said point, about 17 m deep, very close to a dangerous shallow called "La Olla." The first data on this site dates back to 1949 when the local press published a piece of news in which the discovery of the remains of a ship was reported by some divers working to rescue a fishing boat, wrecked near the San Sebastián Castle. In the news, it was pointed out that the remains of gunports, cannons, etc., were preserved at a depth of about 8 or 10 m. The media suggested that these were the remains of a ship that was related to the flagship of the Trafalgar naval combat, the *Bucentaure*. This suggestion was based on information that the Spanish admiral Antonio Escaño provided after the combat, noting that he saw how this French ship touched the stones near the castle of San Sebastián and later sank (Lon Romeo 1950). The first scientific research work carried out on this shipwreck began in the early 1970s, by Olga Vallespín: "It is found at a depth of 16.6 m, on a sandy bottom. It is without question the remains of a ship, of which only the keel and some frames and some 30 iron cannons of a little more than 2 m in length apparently still remain. Sometimes the cannons are one on top of each other, as if when the timber of the deck on which it was found disappeared and that separated them one from the other, the upper one had remained directly above the lower one. Some of the cannons are not among the ship's wreckage, but in a row further on, giving the impression that they have been thrown overboard before sinking as if she had been shedding the ballast to avoid sinking. On the frames and the guns, stretched from bow to stern, is one of the masts" (Vallespín 1985).

Subsequently and in the context of the development of the National Documentation Plan of the Spanish Coast—charge of the Ministry of Culture between the years 1985/87—a series of archaeological charts of the coast (García Rivera and Alzaga 2008) was developed, which in the Cádiz province materialized in the Project "Underwater Archaeology: Prospecting and Assessment of the Submerged Cultural Heritage in the Gulf of Cádiz," as well as in the 1985 underwater archaeological surveys, directed by D. Manuel Martín Bueno, within which geophysical surveys were carried out by using a proton magnetometer and portable magnetic field detectors. Within this project, the Ministry of Culture and the Institute of Nautical Archaeology of Texas carried out an archaeological action in Cádiz under the coordination of Dr. George F. Bass. During the course of the archaeological work, a plan of this site was carried out, which was renamed "Pecio del Imbornal de Cobre." At this time, five iron cannons and remains of the ship's wooden structure were visible.

Since 1999 and throughout different campaigns, archaeological work at this site has been carried out under the direction of the IAPH through the CAS in order to delimit it, acquire data on the assets that comprise it, analyze the state of conservation of the remains, and making, with the collaboration of the University of Alicante, a collection of images for the realization of a documentary called Andalusia Submerged (Rodríguez Mariscal and Martí Solano 2001). During the development of the Specific Archaeological Activity "Experimental application of geophysical techniques for the location, investigation, and dissemination of the Underwater Archaeological Heritage in the La Caleta area (Cádiz)," a series of interventions were proposed for the site in question, which was renamed "Pecio de los Bajos de San Sebastián." During this action, a side-scan sonar was used on the deposit, providing an image of the seabed in which the main elements that make up the deposit can be clearly seen. In 2008 and 2010, geophysical surveys were carried out again, as well as various surveys that allowed a study of both the archaeological materials and the preserved naval structure. The results of these studies yielded the following conclusions:

4.1 Construction System Analysis

The remains of the "San Sebastián Merchant Wreck" belong to a vessel that has been excavated 13.5 m in length and 5.5 m in width, and preserves part of its side, although, with the data currently available, it is not possible to determine whether this side is the starboard or port side. The height of the same and the elements detected in it suggest that it is a fragment of the hull in which the dead and live works of the ship are present. The presence of scuppers lined in a sector of the structure, beside a group of cannons, confirms the existence of a deck situated above the waterline. The remains present a north–south orientation of longitudinal elements although facing south it is possible to see how the different construction features are disappearing due to *teredo navalis* worm and the dismemberment of its constructive elements, dislocating many of the parts disassembled and displacing them from their original position.

The constructive elements describe, in general, a not very robust structure, defined by a cross-link construction technique that, with alternation of empty spaces, shows a predetermined construction sequence. Regarding the axial carpentry, neither the keel nor the keelson has yet been detected, although their discovery is not ruled out in future archaeological works. The transversal carpentry is defined by a set of frames of the ship—a total of 53 lines—in whose arrangement a possible constructive sequence is observed, in which several groups of five frame lines without spaces of separation give a certain solidity to the structure, alternating with double-thick frames separated by empty spaces. This sequence is more clearly seen in the southern half of the excavated area, where they are arranged in their original form.

The dimensions of the frame members are variable between 150 and 180 mm, reaching a height of 170 mm. Regarding their construction, it has not yet been possible to determine whether all the double-thickness frames are assembled laterally through horizontal connecting elements, as a constructive guideline, since so transverse nailing remains have only been documented in two frames of this type. The members, a priori, do not present joints between them by their heads. Regarding the planking of the vessel, a part of the external planking is preserved, as well as the interior one to a lesser extent. The exterior is represented by a total of 10 runs of strakes, best preserved in the southwest area—where eight rows are apparent—while the last strake to the north is fragmented to join the next two in another fragment of the vessel. Regarding their dimensions, they have widths that vary between 260 and 320 mm, with a thickness of about 70–110 mm, with the exception of a longitudinal piece that stands out for its width—25 cm—and for its thickness—around 20 cm—, which can be interpreted as a wale. This would corroborate the presence of a deck in this sector. The inner planking is only present in a small zone of the ship, of which five runs with similar dimensions, 130 mm wide and 130 mm thick, are preserved. Its conservation in situ has ensured the original position of the frames as they remain fastened, like in a sandwich, between the inner and outer planking, by means of the wood nailing to the frames. Regarding the sheathing of the ship, no traces have been detected under the strakes examined. However, some fragments of it scattered in the deposit have been recovered (Fig. 6.1).

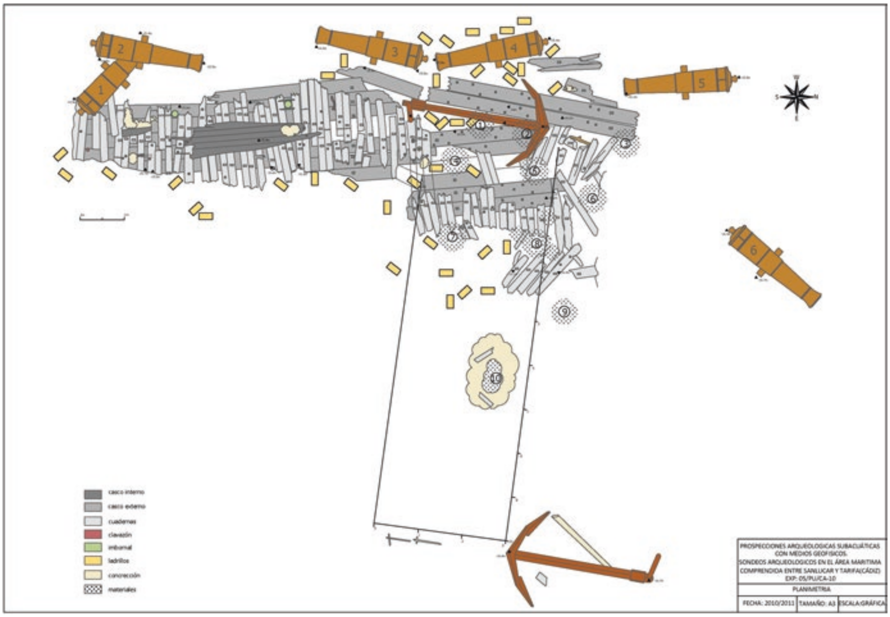

Fig. 6.1 Plan of the Los Bajos de San Sebastián Wreck. (Graphic collection of the CAS. Authors: E. Toboso, N.E. Rodríguez Mariscal)

4.2 Analysis of Archaeological Materials

4.2.1 Armament

A total of six artillery pieces have been located, some of them presenting metallic elements concreted on their surface that make it difficult to appreciate their morphological details. It should be noted that one of the cannons located preserves the axle of its carriage wheels. With the data available to date, the six artillery pieces have similar proportions with a total length of 2,5 m and would correspond to the same caliber (maybe 8), although it is possible to appreciate, despite the numerous elements specified on the barrels, different finishes on the breeches, being able to differentiate up to two formal models, which would correspond to two different regulations or ordinances. In the high band of the stock of one of the guns, its serial number data (n° 2) was observed, providing little information.

Based on the materials located, this would be a small ship, perhaps with a single deck and of Spanish nationality, wrecked between the last quarter of the eighteenth century and the first quarter of the nineteenth century.

Fig. 6.2 Weights and balance plate with detail of the brand; Gun; Sword hilts. (Graphic collection of the CAS. Authors: A. Higueras-Milena, N.E. Rodríguez Mariscal, J.M. Higueras-Milena)

4.2.2 Edged Weapons and Portable Firearms

Of the general set of archaeological materials recovered in the surveys carried out, the items related to portable weapons, such as the hilts of swords, various metal pieces, and an almost complete example of a pistol stand out. The portable weapons localized refer to the armament of the Spanish Navy used from the second half of the eighteenth century. The fact that handles have been found in a stored position and forming a concretion suggests that these weapons were stored—possibly in wooden boxes—at the time of the shipwreck (Fig. 6.2).

4.2.3 Ceramic Materials

These are the most numerous statistically speaking, but it is necessary to point out that generally, it is about small fragments that, in general, correspond to tableware of common use in the eighteenth century.

4.2.4 Glass Material

As with ceramics, the glass materials appear very fragmented and dispersed throughout the site. The base of bottles with a square section sometimes called "gin bottles," stand out from the set, since they generally contained alcoholic beverages. It is a bottle with a short neck and made of mold, due to its symmetry and the fact that the base is smaller than the shoulders. This shape also facilitated their storage on board, since they were normally stowed inside compartmentalized wooden crates (Moreno 1997).

These bottles present a schematic representation of a bell framed in a concentric circle with the legend BLANKENHEYM & NOLET, which indicate the distillery to which the container belongs. This brand also appears on stoneware jugs (Ruíz and Márquez Carmona 2010). As parallels, we can cite the materials from the excavation of the English sloop HMS *Swift*, where this type of bottle appears, although they are larger than those located in the site under study (Elkin 2011).

4.2.5 Anchoring Elements

A 3.4 m anchor and a second 3.45 m anchor have been located. The position of the first suggests that it was stowed inside the ship, ruling out that it was placed in the bow of the vessel as if it could happen in the case of the second. These are wrought iron anchors with a long shank of circular section. They have curved arms, triangular crowns, and the flukes are visible despite the marine concretions that cover them.

4.2.6 Medical Instruments

Some elements have been located that could be put in relation to a space destined to rooms for the sick, where there could be a storeroom reserved for the storage of medicines and the utensils of the trade. Part of an enema syringe, a suture needle, a metal syringe, and a wound cauterizer have been found, as well as a set of small glass bottles that could have been used as containers for medicinal products. A set of weighing elements was also located, specifically three weighing pans and seven weights of different sizes. In some of the weights, it is possible to see the arms of Castilla y León, as well as the weight in ounces, although it is not possible to read, in the upper part of the image, the name of the marker. One of the saucers is marked with the reference “COBOS” (Fig. 6.2).

Parallels of these elements have been found in the Provincial Historical Archive of Toledo, where different sets of weights and measures are located, among which a complete set of octagonal pharmacy weights made of gilt brass stand out.

4.2.7 Personal Objects

In this section, items such as buckles from the nineteenth or twentieth centuries—buttons, personal hygiene items, a medal, and other items stand out.

In conclusion, and after the analysis of the archaeological materials, we conclude that the remains located correspond to a Spanish medium-sized vessel of a military character, chronologically assigned to the last third of the eighteenth century or the beginning of the nineteenth century. The comparison of these archaeological data with the documentary information available for shipwrecks that occurred in this area, and always bearing in mind that the survival of weapons could be extensive, provides the following data: At the moment, there is no information regarding shipwrecks that occurred between 1758 and 1784. In 1805 the Ottoman frigate "*La Gracia*" was shipwrecked; and in 1811 the brig "*Nuestra Señora del Carmen*" was lost, coming from Gijón and under the command of José Vidal. In the part of Tavira watchtower (Cádiz) it is indicated that she was carrying a shipment of bullets.

4.2.8 Delta I Wreck

At the beginning of 2012, the Port Authority of the Bay of Cádiz began the work for the construction of a New Container Terminal located in an area protected by the regional administration as the "Archaeological Easement Zone" and the "Archaeological Zone." For this reason, following the current legislation, the Ministry of Culture of the Junta de Andalucía established the corresponding archaeological precautions that entailed carrying out preliminary surveys with geophysical means—with negative results from the archaeological point of view—as well as carrying out of archaeological controls—during the entire dredging phase, that is, 24 hours a day—in the course of which three wrecks were located, which were called: Delta I, Delta II, and Delta III.

The first wreck found, Delta I, was located in the area where the concrete boxes that would make up the future dock had to be anchored. Due to the dredging activity, the wreck had been left on a kind of compact mud base where it occupied an unstable position. In order not to paralyze the works and to facilitate the excavation of the wreck, it was decided to move it to an area not affected by the new terminal and to a lower depth—it went from 16–19 m to 7–9 m—thereby improving the digging conditions both for visibility and longer immersion time. The transfer project presented by the Port Authority and approved by the Ministry of Culture was carried out with total success, moving it in a block to a place distant about 600 m from its original position. For the excavation, an agreement was signed between Tanit Archaeological Management—a company hired by the Port Authority—and the Andalusian Institute of Historical Heritage—in which collaboration in the excavation tasks and the performance of the desalination and stabilization works of archaeological materials were assigned to the CAS.

The excavation was carried out between May and July 2013 using a mixed grid—rigid and flexible—where the coordinate axis was made of PVC, 22 m by 10 m, with a fore and aft orientation from a center line. Due to poor visibility conditions, each of the four arms of the grid was painted with a different color, the longitudinal lines parallel to the keel in pink and the transverse lines in white. Each square was labeled—2 m × 2 m—with a yellow card; In this way, it was possible for each archaeologist to know at each moment in which area of the ship she was, and thus be able to correctly record each finding that was produced. From the moment which the sediment removal tasks began, using suction hoses, it was found that only the bottom (*plan*) of the ship was preserved, and lying on it was a large amount of stones that were part of its ballast. After the removal of the ballast and the cleaning, it was found that both the bow and the stern were not preserved.

4.3 Analysis of the Construction System

From the naval architecture point of view, it was found that the remains of the ship conserved about 20 m in length by 7–8 m in width. The absence of elements corresponding to the bow and stern did not allow us to know the original dimensions of the ship (Fig. 6.3). The main characteristic of its construction is the robustness of its wooden transversal structure, defined by the design of double-thickness frames separated by a minimum spacing as a clearing. Of its axial carpentry, both the keel and the keelson were preserved in good condition. The keel has an average molded dimension of 27–28 cm and a sided dimension of 31–32 cm. It was possible to verify the presence of three sections of the keel, assembled with flat horizontal scarves. A rabbet was detected in the central area of the ship, disappearing towards the extremities, where the garboard butts against both sides of the keel, reinforced by lateral planks, which run at least the initial and final sections of the keel. It is worth mentioning that a recess in the lower face of the keel was found, at one of its ends, probably towards the bow, which would house a sacrificial piece (in English named shoe) that would act as reinforcement and protection of the keel in this sector.

The keelson, broken after the third floor, which was located at meter 6–7, has a greater sided dimension than the keel, ranging between 410 and 430 mm. It runs in two sections until meter 17.5. It is indented over the floors in the central area of the ship. Regarding the elements that define the transverse structure, it should be noted that a total of 26 double-thickness frames are preserved, corresponding to floors and futtocks designed, in many cases, with chocks and wedges at the ends.

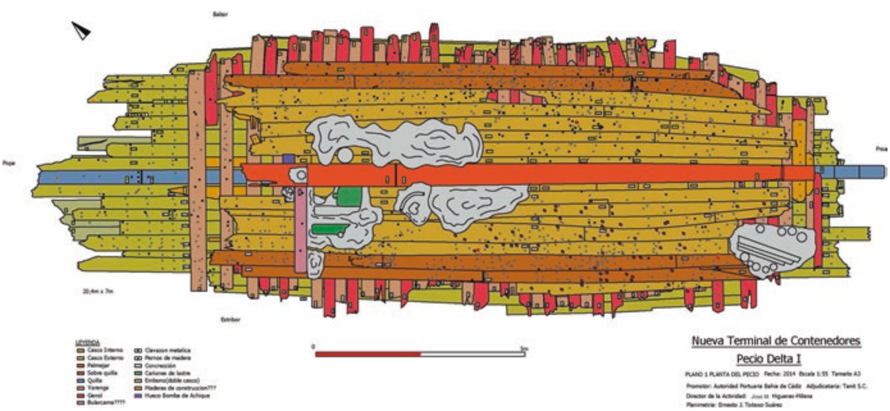

Fig. 6.3 Plan of the Delta I wreck. (Tanit GestiónArqueológica. Author: E. Toboso)

The removal of part of the inner planking, in a sector corresponding to the central body of the ship, allowed access to the overlapping area between the floors and their futtocks. This analysis confirmed the existence of a lateral assembly system between these elements by means of two rows of iron bolts. This type of assembly between frame members is typical of the Iberian–Atlantic construction, defined by the placement of a basic structure called "fastener." This structure is built using the floor-futtock method consisting of the lateral union between frames and futtocks by means of nailing, in this specific case of iron. That is why the spaces between frames are minimal, mainly in the central area of the boat. It is worth mentioning that in the accessible area of the wreck, between the elements that form the frames, there has not been detected any presence of lateral dovetail joints or the use of wooden fasteners.

This construction system gives the ship great strength and weight, which has the advantage of reducing the amount of ballast required. This type of ship was designed for Atlantic navigation. Regarding the dimensioning of the floor timbers, as usual, a widening in the center line is observed, reaching values that oscillate between 370 and 400 mm, observing a narrowing towards the ends. The narrowest piece measures 200 mm while the widest reaches 350 mm. The rest of the floors oscillate between 210 and 300 mm. In the line of the futtocks, at their ends towards the keel, there is a practical absence of spaces. However, the pattern of reduction of the floors towards their heads allows the presence of narrow lateral spaces that favor ventilation between the timbers, thus avoiding the dreaded rotting of the same.

Inside, the floor or internal planking is in very good condition. In the central area of the ship, six rows of strakes were counted on both sides of the keelson, decreasing towards the ends of the vessel. As can be seen in the adjoining Table 6.3, the first of the rows, located on both sides of the keelson, are narrower and fastened to the floors by means of small iron nails. The presence of two stringers was verified, not ruling out, through the information provided by the existing nailing pattern in contiguous floors and futtocks to the second-stringer, the possibility of a third-stringer, not preserved.

4.4 Other Interior Items

At the height of futtock No. 8, the presence of a piece of timber arranged transversely on the inner planking stands out, which runs from the side of the flange to the first stringer, where it ends as a diminishing wedge.

Table 6.3 Delta I wreck: widths of the internal longitudinal elements (cms)

TS2	TS1	6	5	4	3	2	1	KS	1	2	3	4	5	6	TS1	TS2
27	35	34	33	31	33	34	14	43	18	36	26	33	28	33	35	27

The thickness of the strakes of the ground or *plan* oscillates between 7 and 5.5 cm, reaching 12 cm in the stringers

On the other side, the piece has disappeared. However, traces of its presence were detected. The proximity of these pieces to the circular and quadrangular perforations that are observed in the first two strakes, next to the flange, may presuppose that they are reinforcements associated with possible bilge pumps installed in this sector of the ship or, by way of boat ties, as reinforcing elements of a non-preserved mast step. The external planking on the supposed port side and eight rows on the starboard side. The dimensions of its widths were taken on a transversal line drawn at the height of meter 3, obtaining the results given in Table 6.4.

As a protection for the hull, the ship has a wooden sheathing or double-hull installed over a 5 mm layer of well-preserved caulking. An analysis of this compound has determined the presence of animal hair and vegetable fibers, mixed with what could be tar. For the outer layer of planking, lighter timbers were used, possibly pine or beech. The thickness of this layer seems constant in different areas of the boat, reaching 50 mm. Almost 90% of the fasteners observed were treenails. Its use is restricted to fastening the inner and outer planking onto the transversal structure. However, the most important structural elements are fixed with iron bolts located on the centreline—in the keel, floors, and keelson fastenings— and in the construction of the transverse carpentry, fastening floors and futtocks laterally.

As a constructive guideline, with respect to the nailing used, the use of two treenails per strake and frame member can be observed in the outer planking. This arrangement, not noticeable inside the ship at the level of the inner planking, clearly indicates that fasteners were introduced from the outside, a practice that required the prior installation of part of the transverse structure, to which the planking is attached. The hoods of the outer planks were reinforced with iron nails. Not all the treenails fastened the outer and inner planking to the frames, many of them being flush with the floors and futtocks. The inner planking is further secured with iron nails inserted from the inside that have no outlet to the outer planking.

Regarding the water drainage system, it has been possible to document a solution that allowed the creation of channels for the passage of water to the bilge pumps without carving channels at the base of the floors. From the rabbet, the keel rises a few centimeters above the internal face of the planking. Taking advantage of this unevenness and about 5–6.5 cm from the keel, some longitudinal timber was inserted under the floor timbers, running through the ship from bow to stern, giving rise to the drainage channels. No elements belonging to the bilge pumps were located, although there are indications of their possible position. As mentioned above, the existence of two holes made in the inner planking on both sides of the keelson at the level of futtock No. 8 suggests the position of the bilge pump and sump.

Table 6.4 Delta I wreck:Widths of the external longitudinal elements (cms)

7	6	5	4	3	2	1	KE	1	2	3	4	5	6	7
38	13	38	31	25	31.5	30.5	33	30.5	34.5	32	28.5	30.5	6 + 22	28.5

The thicknesses varied between 7 and 8 cm

Abundant stone ballast has been documented. In some areas stones with an angle and a flat base were strategically placed on the inner planking, forming a “floor” on which boulders of different volumes and pebbles are mixed. The presence of iron cannons and different iron elements, such as a fragment of an anchor ring and undetermined iron pieces placed on both sides of the keelson suggest that they were most likely part of the ship’s ballast.

The construction evidence observed in this ship seems to indicate that it is a construction with an important Iberian–Atlantic influence, originally ascribed to the seventeenth century. However, future studies may provide more information on their construction techniques and their chronological assignment.

4.5 Analysis of Archaeological Materials

The fact that only the bottom (*plan*) of the ship was preserved determined that archaeological materials were found, in most cases, among the ship’s ballast and that fragmented or incomplete ceramic remains were abundant.

4.5.1 Ceramic Material

A classification system was used in the study of the ceramics, dividing them according to functional criteria: transport containers (amphoras, jars, bottles, and commercial jugs), storage (jugs, jars, tubs), agricultural–industrial (buckets), hygienic use (chamber pot), multiple uses (basins), kitchen ceramics (pots, pans, lids, mortars, flasks), pantry (daggerboards, albarellos) and tableware (plates, dishes, bowls, bowls, baskets, jugs). The ceramics collection yielded a varied origin in production centers, such as north-western Italy, Portugal, the Rhineland area, or the Sevillian pottery.

Special mention can be made of the jars, storage, and transport containers, which came for the most part from the Triana pottery (Seville). As a curiosity, a type C jar mouth was found sealed with a wooden stopper, when it was usual for them to be made of cork (Fig. 6.4). In the utilitarian and tableware groups were located: “Blue ware” in imitation of the “*ligurianberettina*”—original from Sevillian pottery—whose production lasted until the end of the seventeenth century; “Figurative blue–white” from the second half of that century.

- Italian majolica, documenting both the Pisan graffito and the typical marble of the Arno Valley. Portuguese glazed earthenware among which the Lisbon one with the decoration of “aranhões” from around 1660 and others decorated based on “rendas” or lace stands out, a theme that began to be documented in Portugal around 1645 and experienced a great boom between 1650 and 1680, especially in the production centers of Coimbra and Vila Nova.

Fig. 6.4 Delta I wreck finds:Botija with wooden stopper; Astrolabe; Ponderal. (Tanit GestiónArqueológica. Author: J.M. Higueras-Milena)

4.5.2 Navigation Instruments

Four bronze compasses were found: three arched and one straight, with a chronology of the second half of the seventeenth century. One of the emblematic pieces of the Delta I wreck excavation is the bronze astrolabe found among the ship's ballast (Fig. 6.4). The astrolabe as a navigation instrument is a very important innovation with respect to those used previously since it allowed the pilots to calculate the latitude of the ship's position by measuring the height of a star above the horizon. The one for Delta I belongs to the Ia5 typology by Waters, Stimson, and Castro, the date1606 is engraved and it is made in Spain.

4.6 Measuring Instruments

The weight was used to calculate the weight that the coins should have, they have a series of indications that give the value of their exact weight. The one found during the excavation presents on the reverse a gold shield on the sun (France), sun motif under the crown, and on the obverse, the symbols II MD XV (two deniers 15 grains) the theoretical mass of this coin could be 3.4 grams (Fig. 6.4).

4.7 Silver

During the excavation and dredging work around the wreck, 21 pieces of silver were found, 18 in the form of bars or ingots, and three in the shape of a round or yew. Silver is one of the constants in the transatlantic trade, mainly from Mexico and Peru. The argentiferous outcrops were exploited by hundreds of owners and companies who, in order to obtain their licenses, had to swear that all mineral obtained would, once purified, be sent to the Caja Real, in one of at least two shipments per year. In the Caja Real, the silver was smelted at about 960.5 °C, transforming it into bars or ingots which were then marked. The marks or stamps gave testimony of their legality, origin, grade value, owners, payment of taxes to the fifth real, and assayer, among other information (Fig. 6.5).

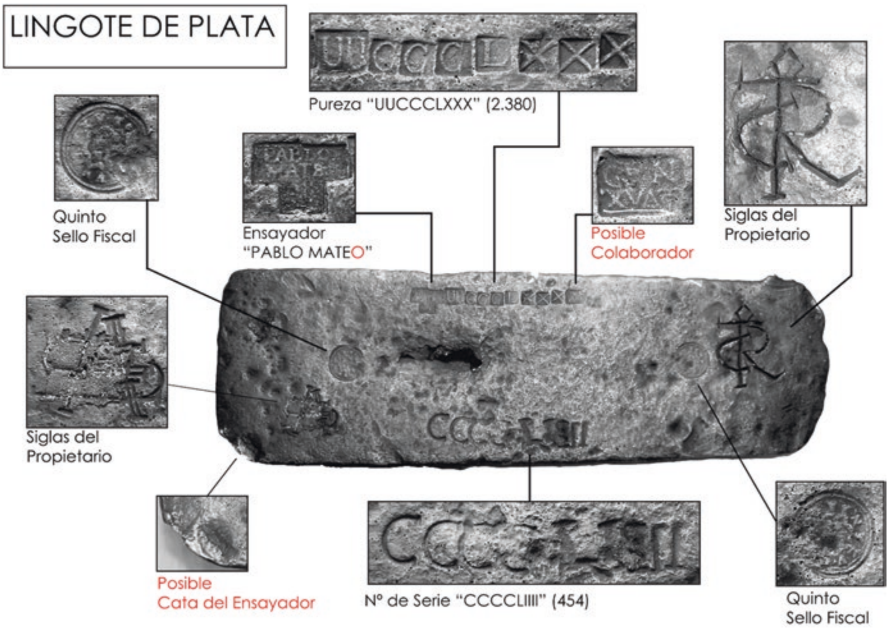

Fig. 6.5 Delta I wreck: Silver bullion. (Graphic collection of the CAS. Author: N.E. Rodríguez Mariscal)

In the case of the Delta I bullion, there are two places of origin—both in upper Peru—those of the Caja Real de Potosí, active between 1575 and 1767, and those of the Caja Real de Oruro, which began its activity in 1607. In 1651, the crown established the "Ordinances to be kept by the assayers in Peru" where it is determined that in addition to the name of the assayer, the casting date must be recorded. Such a date does not appear in any of the ingots, so it is likely that they were made prior to 1651, assuming that the application of the new ordinances had been immediate (Higueras-Milena et al. 2014).

4.8 Armament

A total of 27 pieces of iron artillery appeared during the excavation and dredging of the surroundings of the Delta I shipwreck. Due to the typology of the barrels and the marks located on some of them, on the trunnions, cylinder headbands, and the first teinforce, it was possible to establish that they are of Finbanker type, of Swedish manufacture. "In the mid-seventeenth century, Sweden, a country with abundant iron ore, immense forests and streams for hydropower, began to dominate the European market for cast iron weapons as a result of an energy crisis in England caused by deforestation. Swedish guns were produced in various cities, such as Huseby, Stafsjo, Aker, Ehrendal and Finspang" (Valentini 2015). In eight of the artillery pieces, the letter "H" has been identified on its left stump; this mark identified the cannons from the Swedish Huseby foundry that operated between 1643 and 1800 (Kennard 1986). Given the data collected, it could be concluded that the Delta I is a ship with a constructive system of Ibero–Atlantic tradition, of Spanish nationality, and with a chronological assignment around the third quarter of the seventeenth century (Higueras-Milena and Gallardo 2016).

5 Conclusions

The studies carried out within the framework of the Underwater Archaeological Charter have resulted in the knowledge of both a potential underwater archaeological heritage and a real archaeological heritage. All this information has been the basis on which the legal protection of this heritage has been enacted and sustained and, consequently, its protection against legitimate activities such as infrastructure works. The research and protection of this cultural heritage has led to the location and scientific study of the two shipwrecks of the Modern Age and Iberian–Atlantic tradition described throughout these pages. These documentary and archaeological studies corroborate the historical, geographical, and strategic importance of the Bay of Cádiz throughout history in general, and the Modern Age in particular.

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Chapter 7
Iberian Shipwrecks in the Americas: The Case of the Highbourne Cay Wreck

Nicholas Budsberg, Charles Bendig, Filipe Castro, and Nigel Nayling

Abstract The Highbourne Cay Shipwreck is one of the earliest European shipwrecks in the Americas and may represent a Spanish caravel. As with many other shipwrecks in shallow waters, it was found by sport divers in the 1960s and heavily salvaged. The site was partially excavated and published in the 1980s and revisited by a new team of archaeologists beginning in the 2010s. This chapter details the story of the site, the activities and preliminary results of the last archaeological intervention, and the shipwreck's present situation.

1 Introduction

The Highbourne Cay Shipwreck (HCW) is located in the shallow, fast-flowing waters of Allen's Cut, a narrow channel between Highbourne Cay and Allen's Cays in the northern Exuma Islands, Bahamas (Fig. 7.1). For modern sailors, Allen's Cut is known as one of the best passages for vessels traveling between the eastern extents of the Great Bahama Bank and the deep waters of Exuma Sound. The channel averages 8 m of depth and experiences drastic tidal swings: the current can travel 5–7 kn during the flood tide, switching to 3–5 kn during the ebb. The wreck site is located 150 m from the shoreline of Highbourne Cay and is approximately 56 km southeast of the capital of Nassau, New Providence.

In 1965, three American sport divers located the shipwreck site. Between 1966 and 1967, these divers partnered with a historian from the Smithsonian Institute, Mendel Peterson, who requested assistance from an experienced underwater

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Fig. 7.1 The location of the shipwreck and Highbourne Cay, (**a**) The Bahamas positioned north of Cuba and southeast of Florida, (**b**) Highbourne Cay in the central Bahamas, (**c**) The general location of the shipwreck at Highbourne Cay. (Images courtesy of Google Earth 2021)

explorer and salvor from Bermuda, Edward "Teddy" Tucker. The 1960s team removed most of the visible metallic objects, recorded the site and artifacts, and partially published their findings (Peterson 1972a, b, c, 1974). Most of the work was conducted during a four-month period in 1967 (Fig. 7.2).

In the 1980s, a team of graduate students from TAMU, supported in large part by the Institute of Nautical Archaeology (INA), took an interest in the Highbourne Cay Wreck site after research had begun on the Molasses Reef Wreck (MRW), another early Iberian shipwreck in the Turks and Caicos. These two ships represent the oldest examples of European watercraft in the Americas. The TAMU/INA team revisited the site on two separate occasions: once for a survey in 1983 and again for an intensive excavation in 1986. The team located a well-preserved section of the ship's lower hull and recorded it in detail (Fig. 7.3). No artifacts were removed from

Fig. 7.2 From left to right, Robert Canton, Teddy Tucker, and Mendel Peterson document artifacts removed from the Highbourne Cay Shipwreck in 1967. (Permissions for use received from Wendy Tucker, credit goes to her)

the site and only a few wood and ballast samples were kept for study (Oertling 1987). This activity marked the last time an intensive investigation occurred at HCW for the following three decades.

Since the 1980s investigations, the Highbourne Cay Wreck has been considered as one of the earliest shipwrecks in the Americas. It has also been considered to be conserved in situ, although no investigations or monitoring activities were known to have occurred by either local or international groups since the 1986 campaign. The most recent investigations, led by another team of TAMU students and faculty from the J. R. Steffy Ship Reconstruction Laboratory (ShipLAB), initially began as an assessment of the site's preservation and its potential for further research. Archaeologists were able to verify that the site remained well-preserved, although both human and environmental action threatened its future long-term survival. These observations led the latest archaeological team to begin a multi-phase excavation of the site that would record what still survived while addressing the long-term threats (Fig. 7.4). This phase of the current research is still ongoing with future field seasons planned in the coming years.

All investigations date the vessel to the first quarter of the sixteenth century. The period between 1492 and 1520 is often referred to as the "Age of Discovery" when the Spanish were first exploring the "New World" and establishing what would

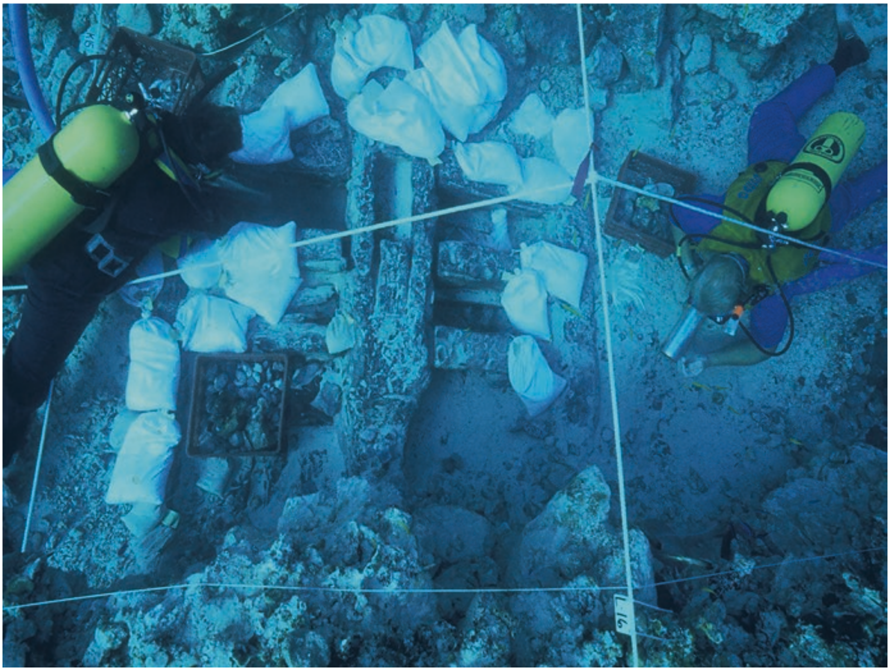

Fig. 7.3 Researchers with the 1986 team excavate the mast step of the Highbourne Cay Shipwreck. (Institute of Nautical Archaeology)

Fig. 7.4 From left to right, Andrew Willard and Liam Phillips exchange a ballast stone while excavating the Highbourne Cay Shipwreck in 2017 (Nicholas Budsberg)

become the largest and wealthiest empire on the planet. Scholars have very little detailed information describing Spanish activities during these early decades, and most sources were written by historians decades or centuries after the events occurred. This issue is especially true for voyages throughout the Bahamas. Sailing through the "Lucayos" archipelago was common during the first quarter of the sixteenth century until indigenous groups were severely depopulated, new discoveries were made further west, and safer sea routes were established. After the 1520s, fewer and fewer voyages occurred through the Bahamas and Turks and Caicos.

Modern scholars also know relatively little about how maritime operations were being organized and conducted especially at the local level. Vessels and their owners needed to make repairs, hire crews, replenish supplies, and replace ordnance and fittings. All these necessities were easy to manage when in Europe, although they became significantly more difficult once across the Atlantic. Further difficulties were created by the sheer distance mariners were operating away from home and the social, economic, and political infrastructure that provided security, stability, and accountability.

The dearth of contemporary information extends well beyond the gaps in the historical record from the European perspective. For every detail missing about Spain's activities in the New World, countless more are missing for the Lucayans, Arawaks, Caribs, and other indigenous groups that called this region home. This is especially true for the interactions between Europeans and Lucayans, the peoples native to the Bahamian archipelago. Initial contact-period sites are important as they can tell the stories of the first meetings and interactions in ways the historical record cannot. Most Lucayans were all but eradicated decades after the arrival of Europeans due to slavery and disease. Ships and boats were inevitably woven into this historical narrative and so their remains create unique opportunities for study; opportunities to learn about these forgotten peoples who unwillingly sacrificed the most during Spain's pursuit of global hegemony.

As a final note, the spelling of the wreck site's name has changed over the years, mimicking (although not perfectly) official changes to the name of the island itself. Researchers from the 2010s will use the spelling "Highbourne Cay," while the 1980s team uses the spelling "Highborn Cay." The 1960s team uses mixed versions of the spelling in publications and notes including "Highborn" and "Highburn," as well as "Cay" or "Key." Other spellings include versions of cay/key mixed with different uses of "high-" and "-bourne." These include "Hi- /Hy- /High-" and "-burn/ -born/ -borne/ -bourn/ -bourne." Some are undoubtedly misspellings or incorrect usages. However, the official name of the island has also changed over time and so some versions reflect this confusing dynamic. A Crown survey from the 1920s uses the term "Hyburn Cay," while a chart from the 1960s uses the term "Highburn Cay." The island's official name in the second half of the twentieth century was "Highborn Cay," although the most recent change came with new ownership and is now officially "Highbourne Cay."

2 Background

The 1960s team concluded that the Highbourne Cay vessel may have sunk in a storm and was a relatively small, lightly built Spanish ship, possibly a pirate or privateer. The lack of personal possessions aboard also indicated to Peterson that the crew had time to get their belongings off the ship before it sank. The team estimated the ballast on the seafloor to be about 50 tons and assumed it to be a vessel of 200 tons burden. The assumption was that the ship sunk while at anchor either from a sudden storm or from previously sustained damage. Peterson also suggested that the vessel was one of the two caravels lost by Vicente Yanez Pinzon in 1500 (Peterson 1974). An edited version of the site plan was published in Peterson's report; however, the original contains more details and is provided below (Fig. 7.5).

The larger artifacts recovered include two wrought-iron breech-loading cannon, three anchors, and as many as 13 wrought-iron swivel guns (although this number is debatable; Peterson reports 11 swivel guns while later records indicate it could be higher) (Peterson 1974; Keith 1988). Numerous, small metallic artifacts were also removed from the site including breech chambers and shot elements of the ship's

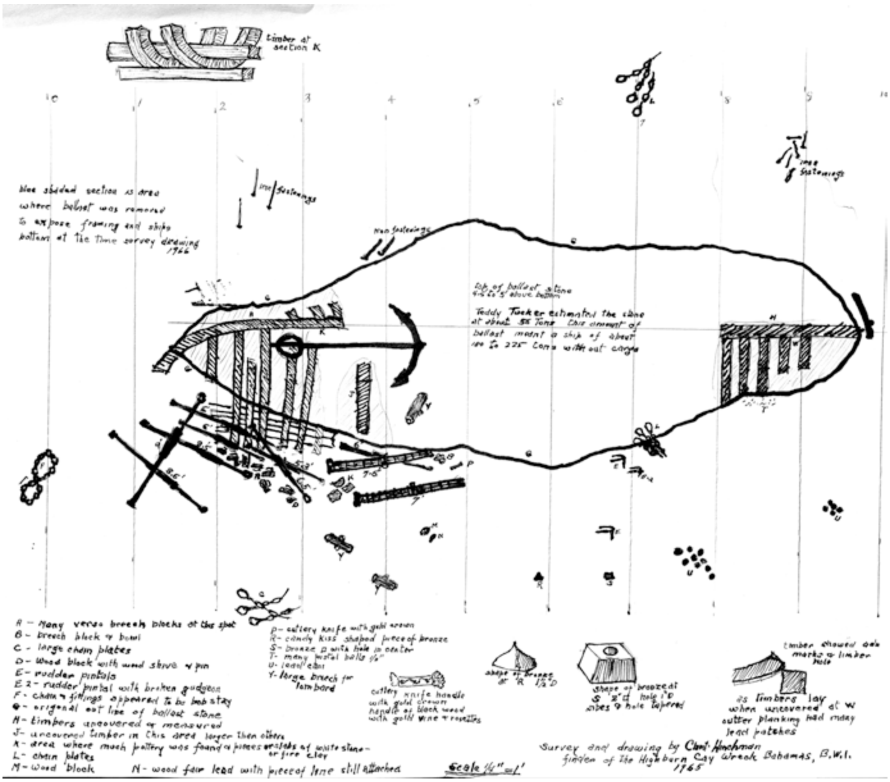

Fig. 7.5 Original 1967 site plan drawn by Clint Hinchmanin 1965 (Mariner's Museum and Park)

rigging, and multiple types of fasteners. Only one personal possession, the handle of a knife, was found during the initial salvage operation and no evidence of cargo was located (Peterson 1974; Smith et al. 1985; Oertling 1987). Some of the objects were conserved and purchased by museums, including the Smithsonian Museum in Washington DC and the Mariner's Museum in Newport News, Virginia. The current locations of the other recovered artifacts, including the three anchors and the knife handle, are unknown.

In 1983, the TAMU/INA research team visited the shipwreck for the first time and over two days performed a visual survey. The team had limited time on site, although their drawings and observations verified that the ballast mound remained largely intact. Hull remains were observed protruding from the ballast pile and small artifacts were found scattered around the wreck site (Smith et al. 1985). There was also evidence of anthropogenic disturbances (possibly attempted looting) identified during this investigation.

INA mounted an extended expedition in 1986 led by Donald Keith to partially excavate the ballast mound. The team was specifically interested in the ship's timbers that were believed to still survive beneath the stones and coral. They uncovered the bow and stern ends of the ballast pile (areas that were previously disturbed by the 1967 team) and added a new trench, which they dug through the center of the mound. The trench exposed an articulated and well-preserved section of the ship's lower hull including the mainmast step and master frame: excellent examples of these construction elements from any early sixteenth-century shipwreck in the Americas. Oertling (1987, p. 13) published a site plan of the activities and the original drawing done by Joe Simmons is provided below (Fig. 7.6). Results of the three-week field season were well published over the following years (Oertling 1987, 1988, 1989; Keith 1988).

This excavation provided the first tangible clues to the lower hull construction of an early sixteenth-century transatlantic ship and to this day remains the best-preserved example of such a vessel. A small artifact assemblage was found during the excavation, although the objects were not recorded in detail and were left in situ. The assemblage was sealed in bags and placed between frames near the mast step

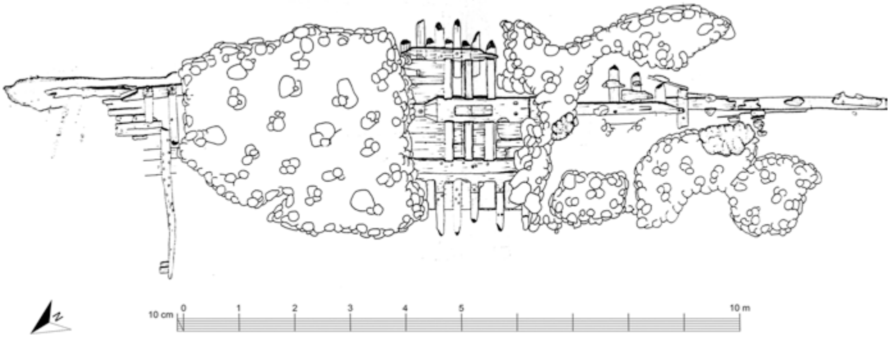

Fig. 7.6 Original 1986 site plan of the Highbourne Cay Shipwreck (after Oertling 1987)

before the site was backfilled with sand and ballast stones. A sign was placed at the site that identified the stones as a shipwreck with the intent of notifying any visitors that the site was known, contained no treasure, and was under the protection of the government.

In 2012, Nicholas C. Budsberg, a doctoral student in Texas A&M University's Nautical Archaeology Program, and Dr. Filipe V. Castro, Professor and Director of the ShipLAB at TAMU, began the Highbourne Cay Wreck: Revisited (HCW:R) project. The study focused on reassessing the site's integrity and research potential. Budsberg contacted members of the previous archaeological team, Bahamian archaeologists, and other stakeholders including local persons, institutions, and related scholars. Between 2013 and 2019, multiple visits were made to the site. The first was a brief reconnaissance to relocate the wreck in 2013 made by Budsberg and supported by Bahamian volunteers. Stuart Cove's Dive Bahamas provided a vessel, dive equipment, and two staff who supported the reconnaissance visit. Volunteer photographers Scott Aranha, with My Deep Blue View, and Laura King captured pictures and video.

Another preliminary investigation of the site was conducted two years later in conjunction with Charles D. Bendig, then a graduate student from the University of West Florida, and with archaeologists, Chuck Meide and Dr. Sam Turner from the St. Augustine Lighthouse and Maritime Museum's Lighthouse Archaeological Maritime Program. The work was supported by the Center for Maritime Archaeology and Conservation (CMAC) and the Anthropology Department at TAMU. Over two weeks, the team excavated a 1.5 m test trench parallel to the keel on the eastern side of the midship's trench dug in 1986. The excavated area allowed the team to expose the surviving ends of the master frame and assess its current state of preservation. The site was visually surveyed over five days using hand tools, photographs, and video. A three-dimensional (3-D) photogrammetric model of the site was also created for reference.

The 2015 visit verified that while some degradation had occurred since the previous excavation in the 1980s, the central timbers were well-preserved beneath the backfill. This observation supported the belief that the rest of the site was also stable beneath the ballast. However, because the current had been eroding an undercut at the base of the ballast it had begun to degrade sections of the timbers once protected by the overburden. One timber fragment was found loose on the seabed near the undercut areas, providing evidence that the timber surfaces were not just degrading but large fragments of planking and ceiling were being torn from the site.

Much of the backfilled ballast in the trench had settled and fallen off the sides, leaving some of the peripheral midship timbers covered with less than 20 cm of material. Backfill on the southern end of the ballast had also collapsed, causing large cavities and tunnels to form between it and the concrete sections. During the survey, it was also evident that intensive human activity occurred sometime after the 1986 campaign, although to what degree is unknown. These observations were supported by anecdotal evidence from Highbourne Cay Resort and Marina staff, dive companies, and locals living in the area.

Sealife and the integrity of the reef structure were visually surveyed to assess how the biological systems had rebounded over the last 30 years. The 1980s team was conscious of their impacts on the reef and made efforts to restore the marine habitat by replanting corals and sponges. Small burrow holes were also created for fish and lobster. These efforts were not in vain. Marine biota was thriving at the site during each visit throughout the 2010s and the broader area supported a variety of complex organisms, including lobster, moray eels, octopus, barracuda, and the occasional sea turtle.

The efforts by the 1980s crew further encouraged the new archaeological team as they returned to the site three decades later. Their previous conservation activities evidenced how a reef system could rebound and thrive even after intensive excavations; an often-ignored component of shipwreck archaeology. This result underscores the importance for future archaeological projects to consider the environmental impacts of their work within their research designs, as even minor actions taken toward reducing consequences to the environment can be fruitful.

The 2013 reconnaissance and 2015 preliminary investigation completed the initial goals of the HCW:R project, although it also raised new concerns about the site's long-term integrity. The assessments helped create a plan for future in situ management techniques, along with limited excavation and backfilling strategies that could be applied to similar sites in the future. These ideas were presented at conferences and discussed with colleagues as methods to be introduced into future studies to test their practical applications.

The most difficult threats to address are those caused by humans: the anthropogenic impacts from treasure hunting, looting, and tourism. The site is located in a remote area of the Bahamas removed from most, but not all, tourist activity. This remote location is both a benefit and a bane. While limited numbers of people visit the site on a regular basis, there are also fewer individuals monitoring impacts to the site or reporting potential issues. To address this component, a robust community-first approach was implemented early on with the goal of educating as many groups as possible and cultivating a network of stakeholders willing to monitor and report on the site.

The HCW:R project was completed the following year and helped justify a follow-up to this work: a project interested in seeing the full excavation, recordation, and if possible, conservation and exhibition of the wreck titled "Converging Worlds: Archaeology and Conservation of the Earliest Surviving Shipwreck in the Americas" (HCW:CW). At a minimum, the site deserved to be better protected from both natural and anthropogenic threats, the unexcavated sections of the hull recorded, and the undiscovered artifacts identified and studied (Fig. 7.7). The authors created the Converging Worlds project with these ideas in mind, which led to a collaborative research design that would incorporate community archaeology and reef conservation alongside nautical archaeology.

The 2017 fieldwork marked the first season of the HCW:CW project and was supported by the National Geographic Society, the INA's Claude Duthuit Archaeology Award, the Orchard Garden Hotel, Stuart Cove's Dive Bahamas, and

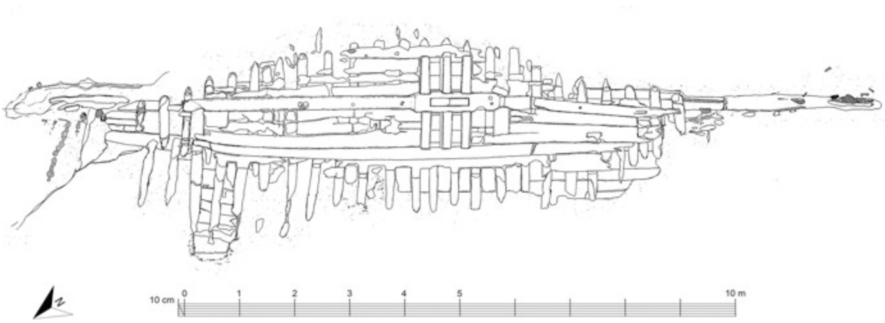

Fig. 7.7 Site plan of the surviving timbers of the Highbourne Cay Shipwreck found onsite during the 2017 excavation (Nicholas Budsberg)

the Highbourne Cay Resort and Marina, as well CMAC, the Explorer's Club, and TAMU's Anthropology Department and College of Liberal Arts. The project was also offered support by researchers from ForSEAdiscovery working under a Marie Curie European Union grant, in addition to being permitted and logistically supported by the Antiquities, Monuments, and Museums Corporation (AMMC), the agency in charge of managing heritage in the Bahamas. The field season included 28 personnel representing 22 institutions across 13 countries and lasted for nine weeks over the summer.

The season was cut short by the arrival of Hurricane Irma in early September. In response to the impending storm, team members had to rapidly backfill the site and secure artifacts and samples in wet storage on Highbourne Cay. The owners of the island and the AMMC are interested in continuing research efforts. Talks with these groups, the University of the Bahamas, and other local and international institutions continue at present. Two more visits in 2018 were made to assess the impacts of the hurricane and fortunately, these were found to be negligible. Local stakeholders living and working in the area also provide frequent updates about activities at the site, the storage of the artifacts, and the return of marine life. The 2020 COVID-19 pandemic ceased all planned travel and fieldwork. A return to the region and forthcoming excavation seasons are planned for 2021 and 2022.

Reports on the work to date were submitted to the Bahamian government and supporting institutions (Budsberg 2013, 2016, 2017, 2018a, b). Project details and developments were shared broadly with the academic and public communities through symposiums, media releases, and presentations. Other visits to New Providence and the northern Exumasduring this period have further helped to build rapport, familiarize the authors with the peoples, culture, geography of the region, and create a supporting network that was heavily relied upon during each field season. The research could not be conducted without the seemingly endless assistance of many Bahamians, along with local and international institutions.

3 Marine Conservation Efforts

Cognizant of the potential negative effects of an intensive excavation on a fragile ecosystem, the Converging Worlds project opted to dedicate a portion of its efforts to better understand and minimize its impacts on the surrounding marine life. This operation began with background research and communications with marine biologists and led to a community-involved plan to gather pre-disturbance baseline data of the coral reef structure and marine biota present. Additional planning involved contingencies for shifting or transplanting coral to encourage regrowth after completion of the fieldwork. Interdisciplinary discussions between marine biologists and archaeologists were also an excellent way to connect the importance of what each group does to local communities who are more familiar with the fragility of coral reefs than submerged cultural heritage.

Prior to intensive activities, a 30 × 30 m area was delineated around the shipwreck to serve as the greater archaeological impact zone. This was the larger area that was likely to be impacted by intensive activities. Fish biomass and substrate surveys were first conducted in this area to gather baseline information about the presence of marine life and the area's productivity. A pre-disturbance photogrammetric model was also created for this area (Fig. 7.8). Photomodeling is becoming a valuable tool for both marine biologists and maritime archaeologists. The pre-disturbance photomodel served both interests here providing an initial map of the sea life and the archaeological materials that later surveys can reference to assess change. The process of creating a photomodel of a large area requires several thousand photographs to be taken, and since each image is referenced within the final 3D model it is easy for researchers in the lab to move frame by frame and identify individual types of marine biota.

A second area measuring 8 × 20 m was then established that encompassed the central ballast pile delineating the primary excavation zone. This zone was going to experience most of the intensive activities and a transplantation plan was developed for this specific area. Sea fans were moved and re-attached to the seabed along with other loose coral structures prior to intensive activities, while other areas were noted for later transplantation as the project progressed. Photogrammetric modeling continued every other day throughout the project providing more detailed records of the activities. Altogether, the pre-disturbance marine-specific components required less than two days and usually occurred in tandem with other archaeological tasks.

Marine biota continued to be transplanted offsite as it was encountered during excavations. Besides the current, marine life accounted for the largest danger to the divers working underwater as species such as moray eels and lionfish inhabited the wreck. Care had to be taken when working on any portion of the ballast pile. Bahamian divers familiar with managing potentially dangerous marine life were a major advantage for the team, as was having personnel with experience working in coral nurseries.

Three other 8 × 8 m areas around the site were also cleared to serve as ballast dumps and drop zones for sandbags. All three zones later became excellent

Fig. 7.8 Orthographic image generated from a photogrammetric model of the Highbourne Cay Shipwreck and the 2017 excavation areas

locations to establish future reef substrates using remaining ballast stones that were not used in the reburial of the wreck. The remaining ballast was organized to create overhangs, burrows, and other cavities for marine life to eventually inhabit. Overall, the project decentralized the original reef structure by moving it from one main location (the ballast pile) to three or more areas immediately around the site.

In the southern ballast dump location, a coral lattice was constructed using vertical pipe and lines that stretched between them. Here, the team incorporated a community component that allowed the project to connect with local youths living on the island. Six Bahamians between 9 and 17 years old participated in an activity where team members gave a brief talk about marine biology and conservation before being ferried to the research vessel. Divers brought fragments of living corals to the surface and the youth helped researchers tie fishing lines and labels to each. These were hung from the coral lattice by divers and each coral bore the name of one of the participants. The children were able to snorkel above the wreck site at slack tide and watch their corals be suspended before being treated to lunch and a question and answer session with the team.

The marine life and the rebounding of the reef continue to be regularly monitored during visits to the site and by local stakeholders who are frequently present. As of fall 2020, a local team member who originally participated in the 2017 project reported that marine life had recovered to its original levels and transplanted corals continue to grow and thrive in the area. During future field seasons, further quantitative and qualitative assessments will be conducted to verify whether the methodologies employed were effective. Future publications detailing the methodology, species identifications, and biomass studies are planned as well.

4 Ballast Pile

The ballast pile was one large concretion when discovered in 1965 with some scattered artifacts lying around the site. After intensive salvage, excavation, and periodic looting over the past five decades, the extents of the ballast had been dispersed and reduced. By 2013, what was once a protective layer of concreted stones had become a porous layer of rock with less than half of the ballast still concreted together (Fig. 7.9). A small area aft of the midship trench dug in 1986 and a large section forward of the same trench remained intact (i.e., concreted) and represented the areas where no intensive excavations had taken place. Erosion of the lower

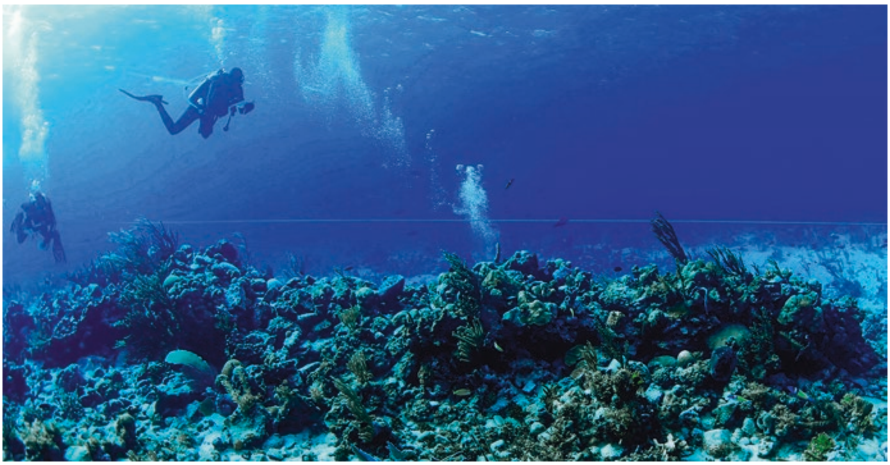

Fig. 7.9 Nicholas Budsberg stretches a tape across the length of the Highbourne Cay Shipwreck while Rudy Ferguson sketches the site from above. (Photo taken by Scott Aranha)

edges of the ballast pile had caused a deep undercut along the site's margins and led to at least one large section of concreted ballast to collapse in the bow.

In 1967, Peterson was the first to estimate the weight of the ballast surviving onsite at 50 tons, although the 1986 team projected the total ballast surviving at the site to be approximately 70 metric tonnes. They also estimated this to be about twice what was encountered at the MRW in the Turks and Caicos (Keith 1988). Estimating the total ballast present at the site is difficult since the 1960s salvage displaced large portions of it to the surrounding areas. Also, the types of stone present vary greatly: some are incredibly light and can be broken into fragments with the strength of a person's hands, while others were hard and far denser. Some of the ballast also contained what appears to be flecks of pyrite or what is commonly called "fool's gold."

The variety of stone types at the site may also be significant, although few detailed studies of ballast stones have been conducted. The 1980s team also noted the exotic-looking stones in the ballast and took samples with the intent of studying them at Texas A&M University's laboratories, however, it is unknown if this occurred (Oertling 1987). During the 2017 field season, some samples of the ballast were collected for future study, although more will be needed to create an accurate representation of what types exist.

Two semi-circular halves of what appeared to once be a grinding stone were also located. The current assumption is that the grinding stone was discarded into a ballast dump (possibly during manufacture due to its rough appearance) and later collected by the ship's crew to serve as ballast. Further study of this object could ascertain if it was used before it was discarded and for what purposes.

It should also be mentioned that no remains of cargo were documented in any of the investigations. The assumption has been that if any cargo were aboard, it was lightweight or organic, maybe even human. No cargo was recorded at the MRW either, which is interesting if it is a similar ship in terms of size and capacity. If MRW contained half of the ballast as HCW and a similar (even if somewhat greater) armament, then it may be plausible to assume a cargo was present on the Molasses Reef vessel and not on the Highbourne Cay ship. Analysis of the dimensions and capacities of the two ships, their ballast, and their ordnance at the time of wrecking may help determine if this is a reasonable assumption.

5 Anchors

In 1965, the sport divers first identified the shipwreck site from an anchor that was lying atop the ballast pile. During the 1967 salvage, two other anchors were found between 100 and 150 meters north of the ballast. These anchors were also believed to belong to the HCW site and all three were raised (Peterson 1974). Either in 1973 or 1974, one of the discoverers returned to the site and raised the fourth anchor from the area, however, the exact location of where it came from was not published (Oertling 1987). After this fourth anchor was removed, it was brought to Highbourne Cay's marina and sunk by the dock where it is still visible today.

The 1980s research team assessed the anchor and could not determine if it belonged to the wreck site (Oertling 1987). Between 2013 and 2017, the research team investigated and recorded the anchor on three separate occasions using analog and digital techniques. A publication of the study of the anchor is currently in production.

Out of the four anchors removed from the site, the largest, a sheet anchor, was one of the two raised in 1967 to the north of the vessel. Peterson (1974) believed this indicated that the ship was in trouble and had rigged the largest anchor to help stop the ship. The strength of the currents in the area where the ship was anchored would also be a justification to rig the largest anchor. Sheet anchors are not only used in times of distress but also when the strength of a larger anchor is believed to be needed, such as when anchoring in a fast-flowing current or an area near a rocky shoreline with unpredictable weather patterns. It is also possible that the sheet anchor was always rigged at the bow out of preference by the captain.

More questions about the anchors, where they were found, their age, and the area where the captain chose to anchor the ship were raised and are part of future research goals. This component of the wreck's study has significant implications for associating an identity with the site and has become a key research focus.

6 Guns

Over a dozen wrought-iron artillery, breech chambers, and shot lay off of the northwest end (port bow) of the ship. The artillery and shot recovered include two wrought-iron tube guns (referred to as *bombardetas*) and four compatible breech chambers. At least 11 wrought-iron swivel guns called *versos* (two are thought to be *versodobles*, a longer type of swivel gun) and15 compatible breech chambers (one loaded with powder and sealed with a wooden plug) were also removed from the site in the 1960s (Peterson 1974). Iron wedges for locking the breech chambers into the back of the artillery were also found, although the exact number is unknown. Lead-cored iron shots of predominantly three sizes (3.5–6.3 cm) were documented in both 1967, 1986, and in the 2010s. Shot of different sizes has also been recorded around the site (Fig. 7.10).

Of the two known museum collections from the Highbourne Cay Wreck, only those at the Mariner's Museum in Virginia have been visited by the authors. These objects are well cared for and remain in excellent condition and were still on display as of October 2019. The materials at the Smithsonian are still being sought, as are the other guns and remaining artifacts that are in their care.

The overall armament recovered from the Highbourne Cay Wreck matches quite closely with those recovered from the MRW. Both vessels carried a similar complement, but it could be said that those found at MRW represent a more heavily armed vessel (Guilmartin 1988). The Molasses Reef site had more breech chambers, weapon types, and a higher number of swivel guns (17) for a ship of approximately the same size (Keith 1987). Both sites had a single pair of large guns (the

Fig. 7.10 Wrought-iron guns and other artifacts raised from the Highbourne Cay Shipwreck in 1967. (Permissions for use received from Wendy Tucker, credit goes to her)

bombardetas) lying parallel to one another along the longitudinal axis of the vessel and each pair had their muzzles pointing in opposite directions. These observations suggest that the guns were stowed below deck and likely lashed together while not in use (Guilmartin 1988; Keith 1988). This consideration is further supported by the historical record. Captain Juan Ruiz Ochoa complains to King Philip II in 1560 (1556–1598) that, "The iron artillery that the Indies ships carry does not help for anything, because in going to sea, they put it under the deck…" (Malcom 2017, p. 151).

One interesting component of the Highbourne Cay Wreck's *bombardetas* is that they are distinctively different guns and thus not a matching pair. Each gun is a different length, has different ring patterns, different muzzles, and (while it may be a difference caused by corrosion over time) different bore diameters by an eighth of an inch (Peterson 1974). Alternatively, Guilmartin (1988) suggests that the MRW's *bombardetas* were made like a fitted set for that particular ship or at least by the same craftsmen and foundry at about the same time. The assumption is due to the similarity of the muzzle decorations, the touchholes on the breech chambers showing very little signs of use (indicating their newness), and because other weaponry onboard also appears to be a pair, such as the two hackbuts. This information suggests that at least some of the ordnance on MRW was purchased at the same time from a single craftsman or even made to order for that ship.

Adopting Guilmartin's reasoning would propose that the guns found at the Highbourne Cay Wreck were not fitted to the ship or simultaneously purchased for a particular voyage. Thus, they are not likely made by the same craftsmen, foundry, or even at the same time. Rather, the guns appear to either be acquired at different times, as second-hand objects or one was garnered to replace another over time. This difference between guns suggests that the ship sunk at Highbourne Cay was not engaged in a specific voyage that it was recently outfitted for. Rather, it suggests the vessel was either active in the Americas for a longer period or that the owners of the vessel were not themselves wealthy, employed by the Crown, or sponsored by another rich benefactor. The MRW could represent a vessel engaged in a planned, lengthy (perhaps royally sponsored) voyage and is likely to be its first one since leaving Spain. The Highbourne Cay Wreck could represent a vessel privately owned and outfitted, active in the Americas for some time, and perhaps engaged in local exploration or slaving voyages.

7 Artifacts

7.1 Iron Concretions

Hundreds of iron concretions were recovered from the site with many larger pieces being removed during the 1960s campaign. Only samples of the wood and ballast were removed during the 1980s research, while just over 500 artifacts, samples, and wooden fragments were recovered during the 2017 field season. Out of this later collection, 182 represent iron concretions. Most of these artifacts appear to be single concretions and 94 appear to be fasteners or fragments. The exact number and identification of each iron concretion will not be known until the pieces can be processed with an X-ray or cleaned and conserved: a priority for future work.

The exact number and type of all the iron concretions removed during the 1967 salvage are not known. The publications by Peterson include drawings provided by Tucker, and a collection of photos from the 1967 work describe some of what was found. It appears that many of the iron concretions were physically cleaned onsite, most likely with hand tools. Measurements and drawings were also completed in the field. Peterson mentions vats were built for temporary storage on the island and freshwater vats were used intermittently for storage on the salvage vessel. Artifacts listed as salvaged in the 1960s include, "2 wrought-iron lombards (*bombardetas*), 11 wrought-iron swivel guns, 4 lombard breech blocks, 15 swivel gun breech blocks, 3 anchors, 2 chain plates, wrought-iron fittings for the swivel guns, and lead cannon shot with iron cores" (Peterson 1974). The list compiled by the 1980s researchers of what was recovered in the 1960s differs slightly from the official report by Peterson (Oertling 1987).

Based on the photographs and Oertling's report, it appears numerous types of fasteners were also recovered, including eye bolts, square-headed wrought-iron nails, and forelock bolts with washers and key wedges. Also recovered were at least three pintles, one with a portion of the gudgeon still attached, and at least three sections of chain plate. Each complete chain plate had a deadeye strap (one with fragmentary remains of wood still attached), three links of chain, and a bolt. A wrought-iron harpoon, wedges for the breech blocks, and possibly one other rigging assembly comprised of a forged ring and two lengths of the chain (suggested by the salvors as a bobstay) were also recovered (Oertling 1987).

During initial surveys of the site in 2013 and 2015, numerous concretions were seen scattered around the area. Anecdotes gathered from local divers and charter companies familiar with the site also mentioned seeing artifacts lying on the seabed. The majority of these appeared to be concretions with others being shot, ceramic sherds, and timber fragments.

7.2 Cupreous Artifacts (Brass or Bronze)

The 1967 salvors also recovered two pieces of bronze. One was described as a "candy kiss" shape and the other as square or rectangular with a tapered hole in the center. The 1980s team identified the latter as a bronze coak or pulley sleeve bearing (Smith et al. 1985). In 2015, two of the authors also located a fragment of wood with a cupreous nail still in place—the only cupreous fastener yet associated with this site. The artifact was reburied onsite in 2015, although not located again in 2017.

7.3 Lead

Two dominant categories of lead were recovered from HCW: thin strips (likely used for patchwork on the hull) and a shot of various sizes. The lead strips varied in lengths and were often bent and twisted, although rarely wider than 8 cm. Many examples had holes where tacks or small nails would have fastened them to the ship or round impressions where the head of the nail had pressed in. Some examples did not have tack holes. The timbers of MRW showed evidence of lead being used as caulking between planking and while this was not identified at HCW in past work, it should not be ruled out as a possibility. None of the lead strips appear to be sheathing or larger sheets meant to cover extant sections of the hull.

The total number of shots recovered in the 1960s is unknown, although their diameters ranged from 3.5 cm to 6.35 cm. A smaller shot likely meant for a pistol was noted on the original site plan as being a third of an inch (0.85 cm). Similar-sized shot was recovered during the 2017 season. One example is approximately 0.75 cm and four other examples of lead-cored iron shots are closer to 5 cm. A larger ball was found on the seafloor further from the ship, although it was not recovered as it was outside the working boundary.

7.4 Ceramics

Ceramics were recovered in the 1960s and the 2010s, but not recovered by the 1980s researchers. The 1980s team conducted a comparative study of three ceramic sherds recovered in 1967 that is currently in the collection at the Mariner's Museum. The small collection was identified as sixteenth-century Hispanic earthenware of two varieties: lead-glazed *melado* and unglazed biscuit ware. The surviving example of biscuit ware and its poor provenance made further identification difficult. The *melado* is among the earliest lead-glazed earthenwares found at sixteenth-century post-contact sites in the Americas. The glazed varieties represented three different utilitarian containers: a jug (*contaro*) and two sizes of bowls (*escudilla*) (Smith 1987).

During the 2017 season, 154 ceramics were recovered ranging in size from less than 1 cm to just over 10 cm. No complete vessels or extant pieces were found. Detailed photographs were taken, and the collection is set to be analyzed in the future. Ceramic sherds were located throughout the site both within and outside of the ballast. Many fragments were found in the northern end of the ballast pile (bow) and match what was noted during the 1960s. A collection of sherds was also found around the pump well and below the ceiling between the frames.

7.5 Non-Wood Organics

Two primary types of non-wood organics were recovered from the site: botanicals and three fragments of bone. Two of the bone fragments were found in the pump sump (alongside the keel) and likely represent a pig or similar animal used as victual for the crew. Analyses of these examples are also anticipated. Samples of sediments from between timber joints remains of caulking from seams, and treenails will also be analyzed for type identification or evidence of pollen.

The largest representation of botanicals is what are believed to be olive pits that were found both in dredge spoil and pressed into the surfaces of the keelson, frames, and ceiling. A collection of six pits were found pressed into the northern end of the keelson, near where many ceramic sherds were also found. This association may indicate where ceramic containers broke up and spilled their contents. Further analysis of these samples will also yield interesting results as to the origin or specific types of foodstuffs onboard.

8 Hull Remains

The ship sank in a highly dynamic area with clear waters and active marine life. Not much of the overall structure of the vessel survived. What is relatively well-preserved are diagnostic elements of the ship's lower hull including most of the keel, frames,

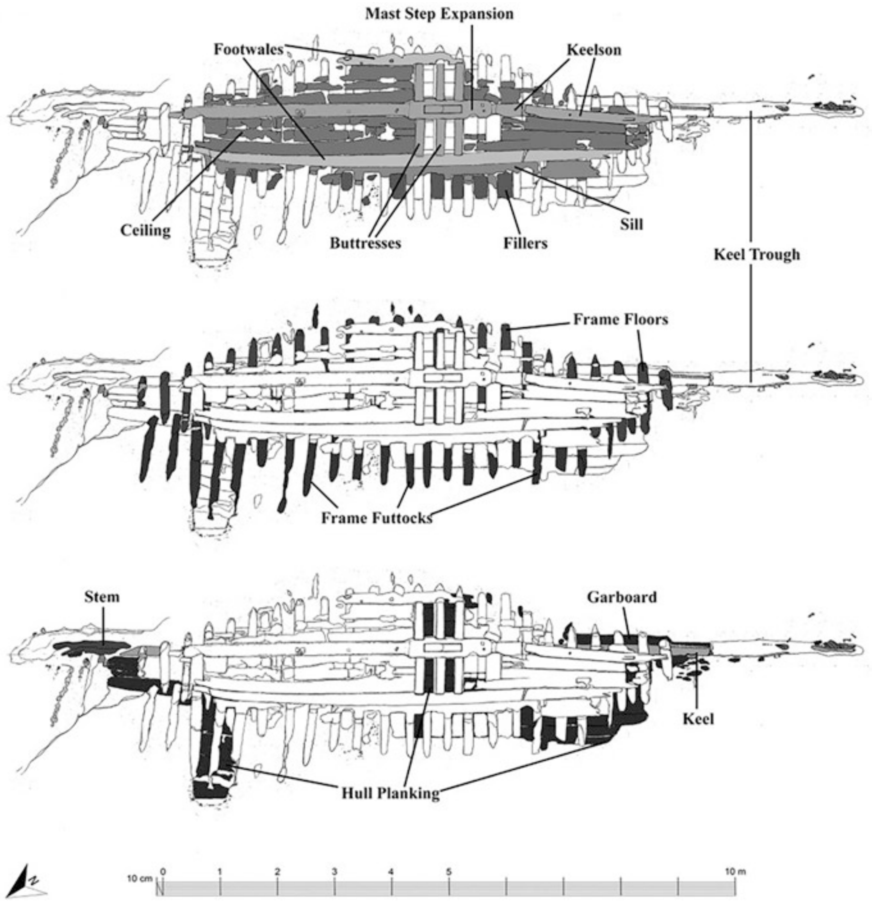

Fig. 7.11 Shaded and labeled 2017 site plan of the surviving timbers from the Highbourne Cay Shipwreck (Nicholas Budsberg)

keelson, and mainmast step. Also surviving is a section of the stem, the chock, areas of the ceiling, limber boards, planking, fragments of stanchions, a shim, stringers, sill, filler pieces, and several very fragmented remains of the ship's pump well (Fig. 7.11).

Impressions in the limestone seabed reflect the locations of timbers from the ship that have since degraded. While the stern no longer survives, a trough gouged into the limestone provides the length of the keel. There is also a large circular depression in the limestone to the port side of the ship which formed as a result of the port half of the hull breaking away when it was pinned beneath the ballast and ordnance. Centuries of this section of the ship slowly grinding away the limestone explains the size and shape of the depression. Many other bolts and fastener heads lie concreted to the seabed around the site, reflecting where other portions of the ship broke up, such as the stern portion of the vessel. The rudder and its hardware also broke away from the stern at some point after wrecking as pintles and gudgeons have been seen on site. At least two were removed in the 1960s, the 1980s team mentioned seeing at least three others on the seabed, and the 2010s team recorded one pintle during its 2017 investigation.

During the 1967 salvage, a large section of the ship's side was found trapped beneath the ordnance that was lifted. This section was likely part of the port hull that helped to form the depression in the limestone. While it was drawn and published, many of the details are difficult to ascertain (Peterson 1974). The hull section did not survive into the 1980s and no remnants of it were seen in the 2010s. Most of the overburden was removed from the site in 2017, but many of the futtocks and planking on the port side of the ship continued past the excavation extents. It is possible some remains of the port side of the vessel are still preserved in the depression. Many key areas of the frames remain covered by the ceiling. The frames are one of the most telling features of the ship's shape and will be a primary focus for future seasons.

Because the site had to be backfilled prior to Hurricane Irma, much of the detailed recordation that was planned for the hull was postponed until a later date. Over a dozen scaled photomodels were made of the excavation progress throughout the 2017 season and help inform ongoing studies, along with numerous scaled drawings created from hull sections prior to the team being forced offsite. Detailed measurements and drawings of the ship's construction and surviving timbers are in progress and will be published soon, accompanied by an updated table of scantlings and vessel size characteristics. For clarity, numerical measurements reported here are taken from the 1980s research so as not to confuse data reporting. Most measurements collected in 2017 from hull remains originally explored by the 1980s team match closely.

Site plans were made in 1967, 1983, 1986, and 2017. A comparison of these plans over time helps inform researchers about site changes and act as a check for accuracy. The site as drawn in 1967 was enlarged beyond its true extents and can be recognized through comparisons with later versions. Also, as Oertling noted about the 1986 plan, researchers believed that the keel was broken beneath the ballast because this timber did not line up from bow to stern (Oertling 1989, p. 250). The extensive excavation during 2017 revealed that this was not the case.

8.1 Keel, Stem, Keelson, and Mast Step

The forward end of the keel and its vertical scarf for the stem survive, although their forms have degraded over time. The total number of pieces of the keel is unknown and the aft section is missing. The stem is heavily degraded and only the lower portion survives at present. A near-vertical rabbet exists along the upper edges of the keel in the stern, although its change over the length of the timber is unknown. There is also a notch on the port side of the keel in the stern. It is roughly the width of a frame and is likely where the "Y" floor timbers started to be tabbed as they rose in the stern. No other notches in the keel were observed.

The keelson is well-preserved and comprised of two timbers: the forward most timber that extends from the bow to aft of amidships and the aftermost piece. A horizontal scarf joins the two timbers; however, no bolt or other fasteners were found in 2017 to affix the two pieces together. The bottom faces of both keelson timbers are notched to fit over the frames. On the aftermost piece, two frames do not have corresponding notches. One frame also rests in a notch that is too large with 2 cm of space on either side. The aftermost keelson timber is also not directly in line with the central axis of the ship, likely a result of the wrecking process.

The foremost keelson timber is the longest found on the vessel and the largest in dimension. The forward end is heavily degraded, although otherwise is in good condition. The upper edges of the keelson were chamfered along both sides on both timbers. The aft end of the foremost piece features the expanded mainmast step, which both rises and widens to accommodate a large mortise for the mainmast heel before reducing again. Each side of the expanded keelson has three notches to receive corresponding buttresses.

Aft of the last portside buttress is two semi-circular recesses cut into the expanded keelson. Both locations suggest separate plans for where the ship's pump was to be installed. The forward semi-circular cut appears to be the first attempt, as the material was much more carefully removed. Someone must have decided that the position was not necessarily the lowest point in the hull and the work was aborted after the carving reached the same level as the associated limber board. Instead, a cruder and slightly wider recess was cut with an adze where the expanded keelson begins reducing its overall dimensions. This second pump sump location was also enclosed by the pump well with a small amount of room inside just aft for maintenance.

The foremost keelson timber also has two square mortises on its upper face: one on the aft end of the expansion and the other closer to the center of the timber. Multiple square-sectioned timbers that fit the dimensions of the mortises were found during excavations and are believed to be stanchions. The locations of these stanchions along the centerline of the vessel likely mark where deck beams were passing above. The aft mortise near the mainmast step is believed to be both a stanchion for the deck, as well as a corner of the pump well. Limited remains of the pump well were identified further aft on either side of the keelson including two stanchions and small fragments of the wall planks.

The foremost keelson timber also shows evidence of four bolts passing into the frames below, three were driven from the top face downward. The other bolt (not shown on the timber plan) was driven in at an angle from the molded, starboard face of the keelson. This bolt is countersunk into the notch for the foremost buttress and appears to be driven into the master frame. This is a peculiar method to fasten the keelson and has no known comparative. It is believed that this bolt does not continue to the keel, but further study will be needed to verify.

The aft end of the second keelson timber is heavily degraded, although it shows evidence of three treenails connecting it to the frame below (one treenail is intact and in situ, while the others are fragmented). Treenails are not seen at any other point along the keelson and it is believed to indicate the aftermost terminus of this timber. Near the center, a single bolt was found driven from the upper face through to the corresponding frame below.

One mortise for a stanchion was noted on the aft end. This mortise is different from the other stanchion mortises found along the keelson, as it is graded with a slope that makes it appear rectangular. Rather than a rectangular-shaped stanchion or tenon, this mortise is believed to be cut in such a way so that the stanchion can be swung in and out of position as needed. This may be evidence of a functional need to remove and insert this stanchion regularly. Or it may be evidence that the aftermost keelson timber is a repair. The odd fastening pattern of this piece and the inexact notch along the bottom face may be explained by such reasoning as well.

8.2 Frames

A total of 24 frames survive along the length of the ship. Concretions of nail heads and fragmented wooden remains provide evidence for another seven frame stations: two at the stern and five more at the bow. In sum, evidence for 31 frames exists, which accounts for most of the original frame stations. Because the exact length of the keel is known and the frames are relatively evenly spaced, it can be assumed that another six to nine frames would be needed to complete the vessel, depending on the spring of the bow, the rake of the sternpost, and the distance between filler frames in the bow and stern (between 37 and 40 total frames on the original ship).

One of the key features of framing on a sixteenth-century Iberian vessel is the type of joint used to connect a floor and futtock of pre-made frames, along with the number and placement of pre-made frames along the keel. On HCW, some frame joints are heavily degraded and will need to be studied further to determine if a dovetail joint is present. Others were not able to be identified before the site had to be backfilled.

Unique frame features include three elements. One of the stern floor timbers shows evidence of scoring marks that identified the turn of the bilge. While vague, the marks appear to be diagonal and in the appropriate places to designate this feature. One of the futtocks aft of the mast step had a shim approximately 3 cm thick placed between the futtock's outer face and the planking. It appears that the arc of the futtock was incorrect and left a gap, which needed to be filled once the planking was attached. This could have been an error made during initial construction but may also indicate the frame was repaired when access to suitable wood was limited. Further investigation of the frame station and if it was pre-made or not will help determine the cause for needing a shim.

Lastly, in the port bow, one of the surviving futtocks was distinctly fractured as its natural curve was being forced to straighten. This timber is directly beneath the area where most of the artillery was recovered in the 1960s and seems to explain some of the wrecking events and site formation. The fracture looks as if it occurred prior to the wood being waterlogged and perhaps relatively soon after sinking (if not during the wrecking event itself). Based on the position of the ballast, artillery, botanical remains, ceramic sherds found in the bow, and the anchor stored in the hold at the time of the sinking, the vessel seems to have sunk bow first. This observation suggests that the ship first swamped at the bow during a flood tide, driving the forward end of the vessel underwater and into the limestone seabed. This action would have rather violently shifted the materials in the hold forward as this occurred. The weight of the artillery and ballast were too great for the timbers to hold and they broke through the port bow area spilling out onto the seafloor.

8.3 Planking

Surviving planking in the area is extensive. The port list of the vessel has resulted in far less of the ship surviving on the starboard side. Evidence of the garboard and at least two strakes are visible in the stern and likely more survives forward of the master frame. One area in the port bow was focused on during the excavation as a means of establishing how much hull still survived, but the full extent were not found. At least 11 strakes were identified on the port side of the vessel.

8.4 Size and Scantlings

Peterson (1974) first discusses the shipwreck's overall size and dimensions referencing drawings and measurements made by Tucker. A set of these drawings are published in the report; however, measurements and scales are not present making specific judgements difficult (Peterson 1974, pp. 238–239, Figs. 9, 10). While some details are present, one drawing shows the presence of a rider keel (also called a double keel) and a false keel (also referred to as a "shoe"). These construction features are more common with vessels built later in the Modern Period and no evidence for them was found in the 1980s or 2010s excavations.

A second drawing shows a cross-section of the keel and a frame amidships, as well as a depiction of a section of the side hull. It does not appear any excavations of the midship area occurred in the 1960s, and the rider keel and shoe are not represented in these drawings. This figure also depicts a section of the side hull of the vessel believed to be from an area beneath the guns. This section of the hull appears on the site plan, although was not present in the 1980s or 2010s and this publication is the only record of this information.

The 1980s research team reconstructed portions of the shipwreck from the partial excavation they conducted in 1986. This includes a scale model reconstruction of the mast step area that is stored at Texas A&M University. Oertling (1989) also published a drawing of the waterlines of the vessel (Fig. 8: 251), and a drawing of the dovetail mortise and tenon joinery (Fig. 7: 250) used between the frame and futtock connections. Note that because the 1980s team believed the keel of the vessel was broken, they adjusted their measurements to account for this break (Oertling 1989, p. 250).

Table 7.1 provides the scantlings and calculations from previous research. A detailed study of the vessel's construction, updated scantlings from the 2017 season, and a hull reconstruction are also currently in progress.

Table 7.1 Scantlings and calculations for the Highbourne Cay Shipwreck from previous research (Peterson 1974; Oertling 1987, 1989; Keith 1988)

Item	Sided (cm)	Molded (cm)	Length (m)	Amount	Note
Length Overall			19		Calculated estimation
Beam			6		Calculated estimation
Depth of Hold			3–4.25		Calculated estimation
Tonnage				50–70 tons	Estimation
Keel	15–16.5	21	12.64		Preserved
			12.75		Maximum
Stem	–	17	1.49		Preserved
Keelson	16–21	17	8.15		Preserved
Mast Step	40	25	1.95		Revealed
			2.25		Estimated maximum
Mortise	15–17 (width)	13.5–15.5 (depth)	65		
Buttresses	13.5 (inboard)	21.9 (inboard)	64.6		
	11.75 (outboard)	16 (outboard)			
Floor (frame)	14–16.5	17.6–21	2.35		Averages
Spacing			40		Center-to-center
Planking	8–25 (width)	6 (thickness)			
Ceiling	21–31 (width)	3 (thickness)			

8.5 Species

The 1980s researchers collected 15 samples from several timbers on the wreck. All but two were a species of oak (*Quercus sp.*). The two exceptions were planks from the pump well that was from the Salicaceae family (includes willows) and the Cupressaceae family (possibly cedars).

8.6 Dendrochronology

During the 2017 season, two members of the ForSEAdiscovery team, Nigel Nayling, and Miguel Adolfo Martins joined the excavations to observe and selectively sample timbers exposed during the excavations. The details of the results of this work and comparison with other Iberian vessels subject to similar analysis are presented in Chapter 1, Vol. 2. Observed timbers were generally in relatively poor condition with eroded surfaces consistent with the increasing exposure of the site observed during previous seasons in the 2000s. Nonetheless, it was possible and facilitated by the excellent visibility and light levels, to note that all the *in situ* timbers examined were of the deciduous oak group (*Quercus* subg. *Quercus*) and tended to be derived from immature trees of fast growth (wide annual rings). The ceiling planks, often very eroded and thin, appeared to be tangentially converted and had probably therefore been sawn from the parent logs. Framing timbers, both floors and futtocks, were generally derived from whole sections of trees where the curvature of the tree section closely followed the hull form at the timber's frame station. The presence of sapwood (or the curved surface of the heartwood sapwood boundary following erosion of the sapwood) was common on this group of timbers. In rare circumstances, complete sapwood and the original bark (waney) edge survived. Samples from these timbers have the potential for delivering precise dating of the felling of the trees used in the ship's construction. Given the relative immaturity of the parent trees when they were felled, absolute dating through ring-width dendrochronology alone is unlikely to prove possible. Nonetheless, developments in oxygen isotope dendrochronology (e.g., Loader et al. 2019, 2020) and refinements in radiocarbon wiggle-match dating (Bayliss et al. 2020; Reimer et al. 2020; van der Plicht et al. 2020) offer possibilities for future approaches to precise scientific dating of this and similar shipwreck assemblages.

9 Conclusion

Between 1965 and 2020, the Highbourne Cay Wreck has experienced significant impacts as it captured the interests of salvors, historians, archaeologists, and the general public. Despite these impacts, a substantial amount of knowledge still lies within the historical material surviving onsite. The study of HCW and its assemblage continues to be justified as so little is known about early Iberian ships, the period in which it was operating, and the peoples and cultures it influenced. Its unknown identity, surviving artifacts, and subtle construction details are all elements of the story that can shape our modern understanding of the past. What this site offers beyond the historical information is a remarkable potential to influence present and future archaeology, Bahamian heritage tourism, and local community development.

The resilient reef structure that has persevered through multiple intensive investigations is a testament to the importance of environmental conservation and its need to be incorporated into archaeological research designs. Experience from the 2017 fieldwork shows the continued promise of future collaborative relationships between marine biologists and maritime archaeologists. At a time when reefs are disappearing at rapid rates and when research into reef resiliency has never been greater, there is a unique opportunity for two formerly disparate research groups to better interact across scholastic boundaries. For regions like the Bahamas that benefit environmentally and economically from their reef systems, it is even more important for archaeologists to speak to concerns about their own impacts on underwater environments.

The commitments made through this project by a variety of community members and organizations are another testament to the untapped desires and possibilities that are present in regions such as the Bahamas. Many groups within the circum-Caribbean rely on tourism as core component of their economies, although they have little familiarity with cultural heritage management concepts. Heritage-based tourism in places like Florida is demonstrative of how investment in this industry can contribute substantially to a region's overall income.

Schools, universities, profit or nonprofit groups, governmental agencies, and individuals are all stakeholders interested in contributing to the study, protection, and sharing of maritime heritage sites. Their interests cannot be harnessed if they remain unaware of the heritage that they already own within their waters and what can be done with such non-renewable resources. Regions like the Bahamas need to invest in learning what sites exist in their waters, how they can be best managed, and how they can benefit local and international people. This approach allows any nation to build a broad framework focused on underwater cultural heritage management that encourages protection, knowledge, and economic growth—three aspects that allow everyone to benefit from shipwrecks and related sites.

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Chapter 8
Spanish Shipwrecks on the Dominican Republic's Coasts

Carlos León Amores

1 Introduction

The large number of shipwrecks on the coast of Dominican Republic has a double explanation. On the one hand, it was the place that Christopher Columbus chose to establish a settlement, first temporary and then permanent, from which to explore the territory he had just discovered and from which other Spanish navigators would depart for different parts of America throughout the sixteenth century. And on the other, in the seventeenth and eighteenth centuries, the Dominican coast would be a place of passage for the galleon fleets between Spain, New Spain, and Tierra Firme. If we add to these unique circumstances that, between the months of June and September, the entire area is the constant epicenter of tropical storms and hurricanes; and that its seabed is full of shallow shoals and reefs, we have the perfect environment for this coast to be among the most shipwrecked in the Caribbean.

The first remains of Spanish-sunken ships, that we know of, were located by the fishermen of Miches who found ancient objects among their nets, recovering them to decorate their houses or sell them as souvenirs of the seabed. In the early 1970s, these increasingly frequent and valuable discoveries alerted the Dominican authorities who tried to put an end to the looting, guarding the coasts, and requisitioning all the historical objects stolen from the sea. On Saturday, June 26, 1976, the national newspaper, Listín Diario, published the discovery and recovery, by the Dominican Navy, of 39 cannons from a sunken ship in the Bay of Samaná (Perez Montás 1997).

The same year, the American treasure hunter, Tracy Bowden, who was then on the island investigating the location of the Battle of Palenque, examined the material

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recovered by the Navy, stating that they belonged to a Spanish ship. At the same time, the Dominican researcher, Pedro J. Santiago, identified the shipwreck as one of the ships of *la flota española de azogues* (the Spanish mercury fleet) lost in 1724, an event described by the Banilejo chronicler Joseph Peguero, in 1762 (Borrell 1983a). Given the significance of the find, the directors of the Museo de las Casas Reales and the National Directorate of Parks, Eugenio Pérez Montás, and Manuel Valverde Podestá, respectively, made the decision to launch an Underwater Archaeology Program to rescue the assets of shipwrecks that were being looted and exhibited in Dominican museums as part of the colonial history of the country.

To carry out this program, two contracts were signed with two treasure hunting companies: first with Tracy Bowden, and later with Burt Webber. According to these contracts, the costs of the future rescue operations would be assumed by their companies, Caribe Salvage S.A. and SeaQuest International Inc., with the Dominican State receiving 50% of the recovered assets. Of the 50% belonging to the salvors, the government reserved the right to acquire all the pieces that, due to their historical or archaeological value, should be accessioned into the collections of the Museum of the Royal Houses, compensating the salvors with coin recovered from the same shipwrecks. The National Parks Directorate was responsible for coordinating this program, while the *Museo de las Casas Reales* and the Cultural Property Inventory Centre were in charge of the historical aspects and the inventory, conservation, and restoration of the recovered material (Perez Montás 1997).

In 1979, the President of the Republic created the *Comisión de Rescate Arqueológico Submarino* (Submarine Archaeological Rescue Commission), based in the *Museo de las Casas Reales* (Museum of the Royal Houses), appointing the Dominican architect and pioneer diver, Pedro J. Borrell, as the first secretary. He would demand that the salvage companies, in strict compliance with the clauses of their contracts, permit the presence of a state official for the duration of each intervention and that the works and inventories of salvaged material were published to make the results known with total transparency.

Although these early interventions very positively disseminated the importance of submerged history, the damage caused by the treasure hunters' recovery methodology was irreparable. Their underwater work techniques did not consider the documentation of the archaeological context of the shipwreck, but simply the recovery of the objects, with a selection based on the financial value of the objects rather than their historical or archaeological value. A common method of removing sediment underwater consisted of the use of large articulated metal elbows or "mailboxes" connected to the ship's propellers to direct a strong current of water toward the seabed leading to the violent scouring of seabed sediments. Explosives were even used to destroy the coral masses that covered the shipwrecks.

In no case was there an archaeological project, nor specialists to undertake the lifting and conservation of the recovered objects. On very few occasions were the wooden remains belonging to the hulls of the ships drawn or surveyed, and in none of the interventions were the sites squared, nor were the objects accurately positioned in their archaeological context. In addition, the extraction of some pieces, such as ceramics or concreted metals, and the elimination of the calcareous and coral crust that had protected the shipwrecks for centuries, left the most sensitive materials, such as wood, leather, bone, or esparto grass discovered, causing immediate destruction.

For a few years the work of this type of commercial rescue companies, almost all North Americans, coexisted with those of the first submarine historians and archaeologists who began to work in the country until, finally, less than a decade ago, contracts with companies of rescue were eliminated to give way only to agreements with universities, foundations, research centers, and museums. Some of the most relevant works carried out with archaeological methodology have been those carried out by the Indiana University Center for Underwater Science, under the direction of Charles D. Beeker, on the shipwreck of the *Nuestra Señora de Begoña* ship and on the Quedagh Merchant pirate ship; those of the Institute of Nautical Archeology of Texas, in the Dutch ship of pipes, directed by Jerome Lynn Hall, or the works of the team of the Project *Galeones de Azogue*, coordinated by Cruz Apestegui, Manu Izaguirre, Pedro J. Borrell, and the author of this work, on the ship *Nuestra Señora de Guadalupe*, in the Bay of Samaná.

Currently, the Dominican government is working on the ratification of the UNESCO Underwater Archaeological Heritage Convention, and on the reopening of the Royal Shipyard Museum, dedicated monographically to shipwrecks and the maritime history of the Dominican Republic, with a selection of 1300 pieces' exceptional items corresponding to twelve shipwrecks from the sixteenth to nineteenth centuries. The new museum, financed with a loan from the Inter-American Development Bank and carried out under the direction of the Ministry of Tourism, presents a modern exhibition, in an air-conditioned space, with magnificent conservation display cases and numerous exhibition resources, such as audiovisuals, models, recreations, interactive, and aquariums. Its opening to the public, scheduled for September 2018, will undoubtedly mark a milestone in the dissemination of underwater archaeology in the Caribbean.

In turn, the National Office of Underwater Cultural Heritage, dependent on the Dominican Ministry of Culture, which preserves some 100,000 historical objects from different sinks, is preparing the Underwater Archaeological Charter of the Dominican Coast, to have a complete and valued inventory of historical shipwrecks, evaluating its state of conservation and its possible risks of destruction or looting.

For our part, the members of the *Galeones de Azogue* Project have carried out in recent years a systematic search of archival information on Spanish shipwrecks, locating documents related to 53 sunken ships off the Dominican coast, from two ships of the Pinzón brothers from 1500 to the ship *San Juan y San Severo*, shipwrecked off the coast of Santo Domingo in 1759.

2 Main Historical Shipwrecks Found on the Dominican Coast

Next, we take a chronological tour of the main historical shipwrecks of the Dominican coast that have been located, intervened through recoveries or archaeological excavations, and of which materials that are currently preserved in the

Laboratory of Underwater Cultural Heritage of the Dominican Republic have been rescued or in the new Museum of the Royal Shipyards (MAR).

3 The Fleet of Nicolas de Ovando in the Sixteenth Century

Nicolás de Ovando arrived in Santo Domingo to replace Francisco de Bobadilla in the government of Hispaniola, who in turn had removed the command from Christopher Columbus by the order of the Catholic Monarchs. Ovando arrived at the port of Santo Domingo on April 15, 1502, after an eventful journey, with some 2500 people embarked on thirty-two ships. Prepared a part of the fleet to return to Spain and ignoring the words of Columbus, who had announced a strong storm, a dozen ships left Santo Domingo. When crossing the Mona Channel, at the height of Saona Island, the presaged storm sank part of the fleet, saving only three of the ships and Francisco de Bobadilla, a staunch enemy of Columbus, died. The strong tropical storm also affected Hispaniola with great damage to the city and the loss of many lives. In 1983, the treasure hunter company SeaQuest International Inc. organized an expedition to search for the remains of this fleet in the area between Saona Island and Catalinita Island, an extremely complex passage in which several objects were found that due to their typology they could belong to one of Ovando's ships, including two artillery pieces: a falconet and a bombard (Fig. 8.1).

Other objects recovered by the Anchor Research & Salvage rescue company, directed by the underwater explorer Robert H. Pritchett, on the coast of Punta Cana, also date from the same century. They are objects that correspond to these first commercial navigations, among which the most notable, a magnificent collection of pewter plates and bowls, several bronze candlesticks, and some extraordinary sets of measures that were used to accurately weigh and value the merchandise. Some personal items were also found in the shipwreck, such as a gold ornament in the shape of a small, decorated basket, a ring, and a decorative bell (Fig. 8.2).

In the archive of the Indies of Seville, news of other sinkings corresponding to this century have been found shipwrecked in different parts of Hispaniola. In Montecristi, the ships *Salvadora* (1522), *Santa Catalina* (1551), and *Santiago* (1583); in Puerto Plata, the Pedro Muñíz ship (1526), the *San Miguel* (1551), and the *San Roque* and *Santa María de las Nieves* ships (1565); in Samaná, the ships *Santa Cruz* and *San Lucía* (1540) and *El Carmen* (1542); on the coasts of Santo Domingo, the ships *Santa María* (1541), *San Juan* (1549), *Santiago* (1552), *Santa Catalina* (1553), *San Pablo* (1553), *San Bartolomé* (1556), and *Consolación* (1564); and off the coasts of Haiti, a Rodrigo de Bastidas ship (1501), a Juan Gómez ship (1552), and the *Nuestra Señora del Rosario* ship (1595).

Fig. 8.1 Lombard and falconet found in the vicinity of Saona Island exhibited in the Museum of the Royal Shipyards of Santo Domingo. (Photo Francis Soto)

Fig. 8.2 Set of weights with oriental decoration from the Punta Cana shipwreck exhibited in the Museum of the Royal Shipyards of Santo Domingo. (Photo: Carlos León)

4 The Galleon *Nuestra Señora de la Pura y Limpia Concepción*

In 1641, a fleet that loaded products brought from China by the route of the Manila Galleon, departed from Veracruz (Mexico). In front was the captain, the galleon *San Pedro y San Pablo*, commanded by Juan de Campos. At the end of the convoy, the admiral, *Nuestra Señora de la Pura y Limpia Concepción*, of 600 tons, built in Havana, in 1620, was sailing. In its warehouses it transported most of the monetary production of the mints of Mexico and Potosí de los last two years, nearly 25 tons of gold and silver, thousands of coins, and a large collection of top-quality ancient Ming porcelain (Fig. 8.3).

Nine days after stopping in Havana, a tropical storm hit the fleet, dispersing it. The galleon *Nuestra Señora de la Pura y Limpia Concepción* managed to save itself, but the ship was damaged. The galleon sailed uncontrollably trying to reach Puerto Rico until, on October 30, at 8:30 in the afternoon, it violently collided with reefs located north of the Dominican coast.

At four in the morning, the ship moved from the place where it had run aground and drifted aimlessly, carried by the wind, to another area of coral against which it collided violently again, this time from the stern. The hull was gradually flooded with water. The passengers and crew took refuge in the sterncastle, but there was no room for so many people. The captain ordered the urgent manufacture of several rafts from the ship's timbers to try to bring the people ashore. Despite attempts to save the crew, more than half lost their lives, in part due to attacks by sharks that flooded the area (Borrell 1983b). On November 11, the *Concepción* split permanently and sank among the coral reefs, about 15 m deep. The cargo was also lost, which was one of the greatest economic tragedies for the Spanish Crown of that century. A year later, the recovery of the cargo was attempted with the help of three ships, but a severe storm and continued harassment from several pirate ships led to the company being abandoned. In 1686, William Phips, a New England sailor, discovered the legend, located the shipwreck, and salvaged part of the cargo for the English Crown. He had the help of fishermen in the area who plunged freely with the help of ballast stones. In their dives, they managed to extract 64 tons of silver in coins and bullion, a good booty that he had to share with the English king in exchange for the title of Knight.

According to Phips' descriptions, the remains of the galleon were found in the middle of the reef, resting between three large heads of coral whose crests jutted out of the sea surface at low tide. Most of the timber had already disappeared, and the coral had grown so large over the remains that, had it not been for its canyons, it would never have been found. For three centuries, the admiral of the New Spain fleet was forgotten, although her cargo gave its name to the place that has since been known as the "Banco de la Plata." Jacques Yves Cousteau himself organized, in 1968, an expedition in search of the remains of the *Concepción*. The famous Calypso tried to find the shallows in which the Spanish galleon was trapped. After several weeks of work, Cousteau and his team of divers found four cannons, two anchors,

Fig. 8.3 Finds from the galleon Nuestra Señora de la Pura y Limpia Concepción, exhibited in the Museum of the Royal Shipyards of Santo Domingo, (**a**) Porcelain foo dog. (**b**) Ming porcelain plate, (**c**) Astrolabe. (Photos: Francis Soto)

and other objects, although they never confirmed whether they really came from *Nuestra Señora de la Pura y Limpia Concepción*.

In 1977, the rescue company SeaQuest International Inc., owned by Burt Webber, organized a localization campaign with the permission of the Dominican government using all kinds of technological means, but after several months of tracking through the coral heads they decided to abandon the search. The following year they tried again with new historical information, and this time they found it. They recovered 60,000 silver coins from Philip IV, plates, trays, spoons, forks, silver ingots, swords, musket balls, kaolin pipes, iron levers, gold chains, a trunk with 1440 coins in a double bottom, jugs, and glass bottles. Years later, the North American company, Caribe Salvage S.A., of Tracy Bowden, signed a new contract to locate the historic ships between Samaná and Banco de la Plata. They had to move many more tons of earth than the previous ones to find three thousand more coins, jewels of great value, and a good part of the cargo in the form of Chinese porcelain.

The seventeenth century supposed how we see the consolidation of a constant trade between Asia, America, and Europe with key ports in Central America, such as Acapulco, Veracruz, Santo Domingo, or Havana an the proliferation of piracy in the Caribbean waters. These maritime routes and the struggles for their cargoes left numerous shipwrecks in Hispaniola. In addition to the aforementioned, our team have collected news of other sinkings: in Saona Island, a ship wrecked in 1603, the *Candelaria* ship and a filibote (1626); In Santo Domingo, the ships *Santa María de Gracia* (1611), *Nuestra Señora de la Regla* (1625), a *urca* and a galleon sunk in 1658; and on the South Coast of Hispaniola, *Nuestra Señora de las Aguas Santas* (1654).

4.1 The Azogue Shipwreck in 1724

The Azogues fleet transported mercury from Almadén (Ciudad Real, Spain) to the port of Veracruz every year or every two years, to later take the mercury to the American mines and carry out the process of amalgamation of the gold and silver extracted. That year, 1724, the quicksilver left Cádiz on July 13. Their commander, Lieutenant General Baltasar de Guevara, gave the order to leave for the west, although the lack of wind made them lose two days at the height of the city of Rota. As far as the Canary Islands, the ships that made up the fleet the *Nuestra Señora de Guadalupe y San Antonio*, with 52 guns, and the *Conde de Tolosa*, with 60 guns, were escorted by the frigate captain Vicente de la Torre, to continue the trip with no other protection than that of his own artillery and his embarked infantry. In its cellars were 8000 quintals of mercury from Almadén, packed in leather *baldres*, placed in small wooden barrels and these, in turn, in wooden boxes. In addition, both galleons transported a batch of bulls, pieces of iron, plowshares, boxes with nails to build a galleon in the Havana shipyard, and cargo of individuals: oil, wine, brandy, and saffron (León Amores and Apestegui Cardenal 1996; Apestegui et al. 1997).

After 37 days of navigation, they sighted the island of Puerto Rico, where they rested for four days while they repaired the *Tolosa* mast that had departed on the journey. On August 23, the commander gave the order to leave for Veracruz (Mexico), the final destination of the trip they never reached. The *Guadalupe* set sail and prepared to leave the cove, however, the *Tolosa* did not set sail. A group of Franciscan religious refused to board because they suffered from a strong sea hangover. A few hours later, the captain managed to convince them to come aboard, promising them good weather and a magnificent navigation. During the night, as they crossed the Mona Passage and sailed north of Espanola Island, the north wind rose. At dawn it seemed impossible to overcome the cape that closes the bay of Samaná. The two ships kept fighting against the north wind that pushed them against the reefs. In the midst of the storm the *Guadalupe* dropped her anchors to hold the ship, but the maneuver was unsuccessful. Suddenly, it collided sharply with the bottom. In the impact, she lost the rudder and suffered serious damage to the stem. She had run aground. More than 80 people jumped into the water to try to save their lives. The *Tolosa* was already out of sight, it also hit the reefs and sank violently at a depth of 20 m. About 600 people died. The next day, with the weather calmer, the commander of the *Guadalupe* decided to take a boat to reach the land and call for help, but a wave overturned the boat and Guevara drowned. Gabriel de Mendinueta, the captain, took charge of the situation despite being seriously injured. They decided then to throw the boat into the water and make several rafts and with them they managed to take everyone ashore.

On the beaches of Samaná, near the Jayán Point, they found the bodies of those who had jumped into the sea the night before. Three days after the shipwreck with no news from *Tolosa*, they decided to divide into groups to seek help by different routes. Some of them boarded the boat heading north, to a place where they believed there was a French port. Others, almost 300, walked south of the island, along the coast, hoping to one day reach Santo Domingo. The third group, which included the sick and injured, waited on the beach until, after 14 days, two shipwrecks from *Tolosa* who were wandering the beaches in search of food, found them and explained that their boat had sunk and that they had all died. Crabs and shells became the only food that kept them alive, in addition to some barrels with wine and brandy that they took from the remains of *Guadalupe*. The third group, made up of some 250 people, also decided to walk along the coast to the south. On the way, dying, without water, without food, and under the extreme heat of the tropical summer, passengers, soldiers, and sailors died (Peguero 1762).

The end of the tragedy of this group came on September 20, when they met some fishermen who came from the town of Higüey, in the interior of the island. The silver master, Francisco Barrero Peláez, then set off on horseback from there to Santo Domingo where he learned that the first 300 who had left the beach had been located a few days before in front of Catalina Island, more than 300 km from the place of the shipwreck, by a small boat that gave notice to the governor of Santo Domingo. Nothing else was known about the boat that left Santo Domingo, when the sloops that left Santo Domingo reached the Bay of Samaná, they found seven survivors from Tolosa who were still on the top of the boat that was sticking out of the water, after 32 days without water or food. A month after arriving in the city, Francisco Barrero Peláez wrote a letter to Don Antonio de Sopeña, president of the *Casa de Contratación de Cádiz*, recounting the shipwreck and the irreparable loss of the King's mercury. This letter, preserved in the General Archive of the Indies in Seville, has served to reconstruct step by step the sinking of the Azogues fleet in 1724.

After 253 years of that tragic event, a group of fishermen from Miches found some jars of oil and other objects from *Guadalupe*. The Navy learned of this discovery and requisitioned the looted material, forcing the fishermen to tell them the place of the shipwreck (Fig. 8.4).

That same year, an agreement was reached with Tracy Bowden's rescue company, Caribe Salvage S.A., for his team to recover objects from *Guadalupe* and find the remains of *Tolosa*. Under the water, you could still see the remains of the two galleons with the boxes that kept the mercury barrels perfectly stowed, boxes with nails, the large barrels with iron pieces, amphorae of oil and tar, cannons with their ammunition, swords, pistols, and thousands of personal items, including many religious medallions, crucifixes and amulets of the embarked Franciscans, a spectacular collection of decorated glass vases, a magnificent Windmills table clock, coins, surgeon's instruments, valuable gold and diamond jewelry, necklaces, brooches, rings, earrings, and a silver bracelet found in *Tolosa* with the engraved name of Antonia Franco (Fig. 8.5).

Between 1994 and 1995, the team of the Azogue Galleons project led by Cruz Apestegui documented the remains of the *Guadalupe* and followed the investigations into this shipwreck, which continues today.

5 *The Frigate* Nuestra Señora de Begoña

A year after the disaster of the quicksilver fleet, a Spanish frigate called *Nuestra Señora de Begoña*, alias Tres Hermanas, ran aground in Caleta de Saucedo, on the coast of Santo Domingo, in a place where there was a small Taino village. The frigate had left Caracas on April 30, 1725, bound for Spain, when a strong storm reached it without being able to take refuge in any port. On May 21, the captain, Teodoro

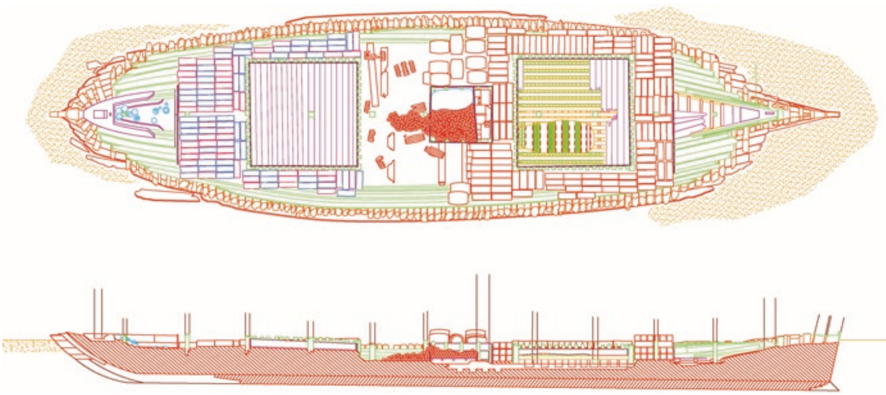

Fig. 8.4 Plan of the shipwreck of *Nuestra Señora de Guadalupe*. (Drawn by Cruz Apestegui and Manu Izaguirre)

Fig. 8.5 Windmills table clock found on the Nuestra Señora de Guadalupe and exhibited in the Museum of the Royal Shipyards of Santo Domingo. (Photo: Carlos León)

Garcés de Salazar, seeing that he could not manage the ship, decided to take it close to land to try to save lives and goods. The ship was wrecked, half-sunk off a small beach between cliffs, but it was able to save the entire crew and most of the cargo of cocoa, wood, and silver coins it was carrying. However, in the investigation carried out by the governor of Santo Domingo, Francisco de la Rocha Ferrer after the shipwreck, a large volume of contraband coins was discovered that the crew hid on the ship. The captain was arrested, charged, and jailed for three years. A team of divers from the area then recovered personal belongings, coins, and two anchors from the frigate, but the difficulties in diving at that time forced the search to stop.

In 2009, a team led by Charles D. Beeker, of Indiana University, in collaboration with The Children's Museum of Indianapolis, The Ely Lilly & Company Foundation, and the United States Agency for International Development (USAID), located the site and has been working on this shipwreck for several years with interesting finds, including concrete blocks of silver coins from the mints of Mexico and Lima, musket ammunition, a cannon, Spanish ceramics, Taino ceramics, a barrel tap of wine, and silver dishes with remains of the trunk that transported them, among others. In addition to the findings at sea, Bekeer's team has carried out extensive historical research work in the Spanish archives to learn firsthand the testimonies of the survivors and the court records. Some sailors mention that the coins were in bags of one thousand to one thousand pesos, a common measure in the transport of Spanish silver coins. This has been verified in some finds under the sea that effectively still preserve the shape of the bags and contain a thousand silver coins.

Among the remains of this shipwreck, the state of preservation of the elements that made up the kitchen is surprising, huge metal cauldrons with their lids, saucepans, pans, saucepans, and skimmers, which tell us about the food on eighteenth-century ships. Another group of recovered objects have to do with navigation, among them a magnificent sextant made of wood, bronze and ivory, and several pointed compasses. But if something characterizes this shipwreck, it is the weapons and clothing accessories of French soldiers and sailors: swords, sabers, buttons, buckles, insignia, pectorals, a rifle, a pistol, a wooden holster, flintstones, and ammunition of different calibers. Also, as in other shipwrecks, the presence of wine bottles and common tableware, ceramic, or pewter, is very numerous. The discovery of the key to a wine barrel in perfect condition and several bottles of wine still with the liquid inside is surprising. Research work carried out in archives tells us about other ships sunk in the eighteenth century off the coast of Hispaniola: in Montecristi, the ship *San Sebastián* (1782); in Puerto Plata, a shipwrecked urca in 1718; off the coast of Santo Domingo, 13 ships sank in 1751, the ship *San Juan y San Severo* (1759), *San José y las Ánimas* (1784); a sloop sank off the South Coast in 1731.

6 The Future of the Underwater Cultural Heritage in Dominican Republic

These historic shipwrecks are a sample of the archaeological potential of the Dominican coasts. Their future depends on the decisions that the government will take in the coming years with regard to the implementation of a true master plan on the investigation, protection, surveillance, and dissemination of this unique heritage. The termination of contracts with treasure hunter companies has undoubtedly been an essential step on this path, but it is also true that institutional neglect and the scarcity of resources available to the country can be so damaging, like looting. And this problem is aggravated each year with the progressive increase in the number of sport divers exploring Dominican waters, and with some large-scale port infrastructures that threaten with the dredging of huge extensions of the seabed in hitherto virgin areas.

The model followed so far by the Dominican government has generated a varied typology of treasure hunters and underwater pseudo-archaeologists who join the clandestine plunderers. Many of them have sufficient infrastructure to remove sediments and deepen the deposits, causing great damage to shipwrecks. They have boats with their permits in order, diving equipment with their qualifications, compressors, metal detectors, ROVs, side-scan sonar, magnetometers, cranes, and other accessories. Among these companies are some that are publicly traded and have known capital partners or shareholders, and other sole proprietorships or family businesses. They tend to alternate wreck "rescue" jobs with other professional diving jobs, or even rent their resources to third-party companies. Given their size, they are companies that hire historians who work in the archives with the aim of gathering information on the shipwrecks, sometimes through intermediary companies, so as to not give many clues when it comes to state ships on state missions. Pseudo-archaeologists, quite numerous in these waters, usually work under the umbrella of renowned universities, although they are not specialized professionals, or they are in other subjects that are very different and far from archaeology. They usually collaborate with international foundations or with sponsoring brands. Their lack of scientific criteria leads them to report great findings with little proven evidence. In general, they are not very destructive interventions since, almost always, they focus on a specific shipwreck and not on an area, as rescue companies do. In addition, due to their pedagogical nature, it is common for them to work with university volunteers and therefore, their campaigns are usually short-lived. In most cases they do not have large media and tend to publish their results, although with weakly founded conclusions.

For our part, those of us who make up the team of the Galeones de Azogue project, which began its activity in the Dominican Republic in 1994, have fought against these forms of work by proposing as an alternate a different model of research, strictly archaeological, on the ship *Nuestra Señora de Guadalupe* with periodic cargo documentation campaigns and studies on architecture and shipbuilding, publishing the results in various books and research articles and giving numerous conferences in different museums and universities. The fact of working on two ships that had already been investigated by a rescue company in the 1970s has not been an impediment to continue obtaining a large amount of information and documentation from the two sites. This new archaeological information has been the basis for generating new hypotheses about this shipwreck, about the transport of mercury, and about the Creole shipbuilding of the eighteenth century.

In 1997, we participated in the *Huracán 1724* exhibition, financed by the La Caixa foundation, with an innovative museum proposal, presented at the Barcelona Science Museum and at the Cosmo-Caixa Museum in Madrid, with a selection of archaeological materials Dominican underwater. Between 2016 and 2017, we participated in the selection of all the materials for the new Royal Shipyard Museum (MAR) and in the technical direction of the museum's contents, drawing, among others, the construction plans of a longitudinal section, at size real, from the first battery of the ship *Nuestra Señora de Guadalupe*, which shows how the artillerymen fought, slept, and ate. We have also directed the documentary "The Shipwreck of the Azogues fleet of 1724" and drafted the "Museum Guide" with a clear educational vocation. This museum, modernized within the framework of the Colonial City Tourism Promotion Program directed by the architect Maribel Villalona is, today, the country's greatest commitment to the dissemination of underwater archeology, and will be the perfect setting for the future ratification of the UNESCO Convention on the Protection of the Underwater Cultural Heritage, announced by the Minister of Culture and president of the Dominican National Commission for

UNESCO, Pedro Vergés Cimán, at the National Workshop on the Protection of the Underwater Cultural Heritage, held in Santo Domingo, in December 2017, with the collaboration of the Spanish Agency for International Cooperation and Development (AECID).

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Chapter 9
The Timbers of the Frigate *Santa María Magdalena* (Eighteenth Century): A Spanish Warship in History and Archaeology

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Abstract The case study of the eighteenth-century Spanish frigate *Santa Maria Magdalena* constitutes one of the opportunities given to the ForSEAdiscovery project team to approach the subject of shipbuilding and timber supply in the Iberian Empires of the early modern age, in an interdisciplinary way, through the combination of efforts of three different disciplines: history, through the research of written sources; archaeology, through the collection and study of the material evidence of ships; and wood science, through the analysis of timber samples from archaeological sites and old living trees.

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Fig. 9.1 Location of the *Magdalena* shipwreck site in Viveiro Bay

1 Introduction

Driven by the increased demands on seafaring defense, the Spanish Crown launched the S*anta Maria Magdalena* frigate from the Esteiro shipyard of Ferrol (Galicia, northwest of Spain) in 1773. In 1810, the ship wrecked at the bay of Viveiro (Fig. 9.1), in the context of the Spanish War of Independence (1808–1814). In June 2015, the ForSEAdiscovery project organized an underwater timber sampling campaign on this shipwreck site. Through various wood provenance studies (i.e., dendrochronology, inorganic, and organic chemistry), combined with historical research in national archives and international sources, such as the *Sound Toll Registers*, the frigate's timbers have the potential to shed light on late eighteenth-century Spanish naval construction, forestry practices, and timber supply in relation to shipbuilding in northern Spain. As a highly interdisciplinary project, ForSEAdiscovery integrates research fields in the humanities and life sciences. This paper presents the joint efforts of historians, archaeologists, and wood scientists to determine (1) what kinds of trees were used to construct which parts of the *Santa Maria Magdalena*, (2) their provenance, (3) the timber trade networks and state management involved in supplying wood to the Ferrol shipyard, and (4) best practice methodologies to reach these conclusions.[1]

[1] This chapter constitutes a revised and enhanced version of Trindade et al. 2020.

2 Historical Background

In the early 1770s, King Charles III (1759–1788) was developing the policy of shipbuilding initiated by his predecessors as part as the so-called Bourbon Reforms. These consisted of a program of economical and administrative restructuring in which a new conception of a centralized Navy took a prominent role, as the key factor of the maintenance of a vast colonial empire. In this context, the arsenals of Cartagena, Cadiz, Ferrol, and Havana became the centers of the state-controlled shipbuilding industry (Merino Navarro 1981).

On August 1, 1772, a Royal Order announced a program of construction of three *urcas afragatadas,* and one frigate to be carried out by the Esteiro shipyard (Arsenal of Ferrol), and this is the begining of the story of *La Magdalena*.[2] According to payment orders of salaries to the shipwrights, its construction began in September and lasted for the next 10 months.[3] The official launch took place in Ferrol on July 7, 1773, and the document of its announcement described the vessel as a 26–34 gun frigate, 145 feet long.[4] After 37 years of serving the Spanish Navy in Atlantic waters, the *Santa Maria Magdalena* sunk in the Viveiro bay (Lugo province, Galicia, Spain), along with the *bergantín Palomo*, in the context of the Spanish War of Independence (1808–1814). In November 1810, these Spanish vessels took part in an Anglo–Spanish squadron which fought against the French occupation of Santoña (Santander, Spain). On the night of November 2, after being hit by a severe storm, the *Magdalena*, *Palomo*, and a few other vessels had to evacuate Santoña and took shelter in Viveiro. The damages inflicted by the storm, such as the loss of the anchors, determined the fatal outcome: the *Magdalena* collided with the English frigate *Narcissus*, crashed against the Reef of Castelos and sunk soon after, taking the lives of 20 members of the crew (Fernández Duro 1867; Gambón Fillat 1976).

2.1 History: Timber Supply in Ferrol (1771–1773)

Historical research aimed to obtain information about the construction process and main features of the *Magdalena*, as well as the model of timber supply in Ferrol during the late eighteenth century.

Archival research was mostly centered on the Spanish sources of the Navy administration corresponding to the section of the Navy Secretary (*Secretaría de*

[2] Archivo General de Simancas (AGS), Secretaría de Marina (SMA) 349, August 1, 1772.

[3] AGS, Tribunal Mayor de Cuentas (TMC), 4207: October 16, 1772; AGS,TMC, 4207: November 17, 1772; AGS,TMC, 4207: December, 16, 1772; AGS,TMC, 4208: January 22, 1773; AGS,TMC, 4208: February 20, 1773; AGS,TMC, 4208: March 18, 1773; AGS,TMC, 4208: April 20, 1773; AGS,TMC, 4208: May 20, 1773; AGS,TMC, 4208: June 21, 1773; AGS,TMC, 4208: July 24, 1773; AGS,TMC, Marina, 4208: August 20, 1773

[4] AGS, SMA, 350: July 7, 1773

Marina - SMA) and state accounts of the court of auditors (*Tribunal Mayor de Cuentas,* TMC) from the Archivo General de Simancas (AGS), in Valladolid, Spain.[5] In order to further investigate the subject of timber import from Northern Europe, the research involved cross-reference with the Danish database of the *Sound Toll Registers Online* (STRO, last viewed 31 March 2017), which records the passages of merchant vessels and their products, from Baltic ports to their destinations, through the Danish Sound (Gøbel 2010).

Besides the information regarding the shipbuilding process and main features of the frigate, the researched sources did not contain any further data specifically related with the *Magdalena*, such as the timber used in its construction. Therefore, the team decided to work with historical documents dated from 1771 to 1773[6] about all the aspects of timber supply to the Ferrol Department, in order to identify the whole context of timber acquisition. These documents cover the period of construction (1772–1773) and the previous years, during which some of the timber used in the *Magdalena* might have arrived. Thus, the sources from AGS allowed the identification of three major regions of wood supply: Northern Spain, Northern Europe, and the Caribbean. Each of these major regions provided specific species and types of ship elements, and that is related, not only to the natural habitats of the trees, but also to the economic and technological strategies behind this model of supply.

2.2 Northern Spanish Timber

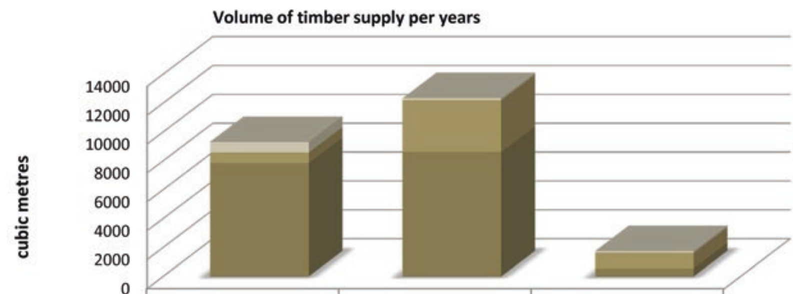
The quantification of northern Spanish timber supply involved the examination of 58 documents from the following archive sections and subsections: *Secretaría de Marina,* subsection *Arsenales* (units 347, 349, 350), subsection *Asientos* (unit 621), subsection (unit 788); *Tribunal Mayor de Cuentas,* subsection *Marina,* Ferrol (units 4207, 4208). The quantitative data provided by the Spanish sources was unevenly presented in units and volume (*codos cubicos* - cubic cubits); in order to calculate the volume of timber elements, we searched for their approximate measurements in *codos*, within the *Pie de Burgos* measuring system, according to the piece typologies of presented by Francico Gautier in 1769[7] and Romero Fernandez de Landa (Fernandez de Landa 1784); the volume of Nordic pine pieces was calculated according to the measurements of the masts, spars, and planks listed in the informs of timber needs for 1772 and 1773.The volume calculations (Marien y Arróspide 1789; Aranda y

[5] *Secretaría de Marina,* sub-section *Arsenales* (units 347, 349, 350), sub-section *Asientos* (unit 621), sub-section *Registros* (unit 788); *Tribunal Mayor de Cuentas,* subs-section *Marina,* Ferrol (units 4207, 4208), in a total of 97 documents.

[6] Sound Toll Registers Online, viewed March 31, 2017, http://www.soundtoll.nl/index.php/en/over-het-project/str-online. Except in the case of the data from TMC and STRO that was used in the cross reference of Northern Europe timber trade, which was extended to 1770.

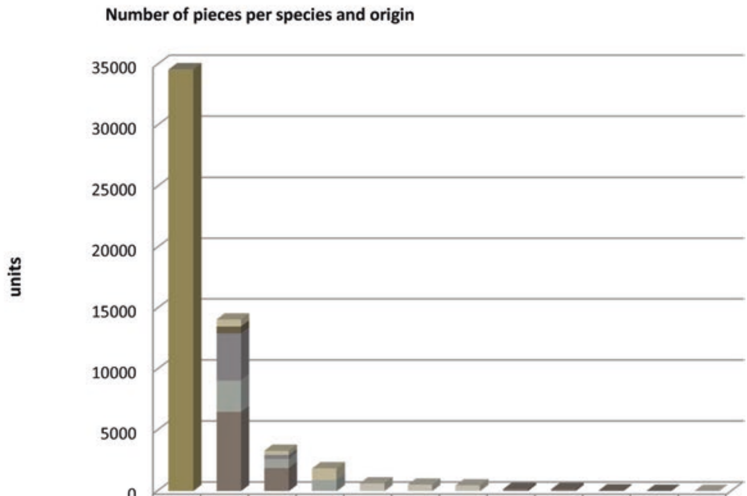
[7] Gautier, F. 1769. *Reglamento de maderas de Roble necesarias para fabricar un Navio de 70 Cañones*. Mss. San Lorenzo, November 11, 1769; AGS, MPD, 41, 033bis. Ubicación Anterior: SMA, 0034215

a



	1771	1772	1773
Caribbean	743	134	127
Northern Europe	732	3598	1064
Northern Spain	7845	8612	563

b



	P.	Q.	F. G.	Q. I.	C. 0.	G.	Trop Und	P. N.	J.R.	A. G.	F. E.	T. E. L. L.
Caribbean					653	526	475					20
Northern Spain Und.		572	355	942								
Navarra		568										
Northern Spain: Guipuzcoa / Navarra		3858	307									
Northern Spain: Cantabria		2593	754	924								
Northern Spain: Asturias		6500	1901					183	155	72	38	
Pyrenees	59											
Northern Europe	34550											

Fig. 9.2 Volume and number of pieces by origin, Ferrol 1771–1173 (AGS, SMA, 347, 349, 350, 621, 788; AGS, TMC, 4207,4208)

Table 9.1 Number of timber pieces per species and type, Ferrol 1771–1773. (AGS, SMA, 347, 349, 350, 621, 788; AGS, TMC, 4207,4208)

species / type of piece	pine (P.)	oak (Q.)	beech (F.G.)	holm oak (Q.I.)	cedrela (C.O.)	guayacán (G.)	tropical (und.)	black popplar (P.N.)	walnut tree (J.R)	alder (A.G.)	ash tree (F.E.)	chicharrón (T.E.)/sabicú (L.L.)
planking	34370	4218	2436						16			
futtocks		3859			602							
undetermined		1058		924		502		97	5	72	3	
unprocessed timber		582	686			24		86	134		35	
beams		1278	195									
axis for guncarriages				942								
knees		562										
wales		486					68					
waterways		367										
stringers							333					
floor timbers		327										
pegs		306										
masts and spars	194											
ledges		190										
top timbers		150			31							
stanchions		137										
keels		30			14		26					14
counter timbers		65										
pieces for hawseholes		55										
innerstern posts		49										
main masts	45											
cruchers		45										
shelf beam		40										

sheer bitt		38										
keelson		26			6							6
anchor stocks							35					
stern knees		32										
buttocks		25										
sternposts		20										
masts steps		19										
riders		19										
v-frames		17										
chocks		16										
bill step and the for emast partner		16										
spritsail yards		16										
fashion pieces		14										
stern panel timbers		9										
bitts		4					5					
tillers		2					6					
stern dead woods		6										
sternsons		2										
cathead		2										
bulwarks		2										
stern timbers		2					2					
TOTAL	34609	14091	3317	1866	653	526	475	183	155	72	38	20

Antón 1990)[8] indicate Northern Spain as the main area of provenance of the timber used in Ferrol at the time of the *Magdalena's* construction, corresponding to 73% (sum of 17,020 m^3, during the years 1771–1773) of the total supply (23,418 m^3) (Fig. 9.2a). Such preponderance is expressed, as well, in the diversity of species, from oak to ash (Fig. 9.2b) and, especially, in the diversity of the typologies of ship pieces (Table 9.1). However, the quantification of pieces per units does not reflect the majority of Northern Spain timber, as this place is occupied by Northern European pine planking, masts, and spars. In terms of units, Northern Spain timber corresponds to 35%, in a total of 19,781 pieces out of 56,005 (Fig. 9.2b and Table 9.1). This discrepancy between volume and quantity is explained by the nature of the ship elements. In fact, Northern Spain timber was, by far, the preferred choice when it came to the structure of the hull and other elements below the waterline, which correspond to very voluminous elements, when compared to planks, the most abundant type of piece (Table 9.1).

Oak (*Quercus*) grew in Northern Spain's forests in special abundance, and this was the primary timber for those kinds of ship elements (Aranda y Antón 1990, 1999), contributing to this region's tradition as a strong peninsular center of shipbuilding, at least since the sixteenth century (Goodman 1997). Proximity to timber sources was an obvious criterion of choice, since it not only facilitated transport (costs and infrastructures), but allowed the close control of trees by the naval engineers and shipwrights, in order to assess quantities and quality in terms of material, shape, and size (Aranda y Antón 1990; Wing 2015). The multiplicity and specificity of typologies of the structural elements of the hull, and other pieces to be placed below the waterline, the measurements of which varied according to the size, scantling, typology, and shipbuilding technique, can be seen in the treatises, wood regulations[9](Fernandez de Landa 1784),[10] as well as reports of shipwrights and engineers boards. These required closer supervision than the pine planks, deals, masts, and spars used in the upper works, which were massively produced and purchased from the Baltic region in varied, but rather standardized measurements, for multiple purposes (Gallagher 2016).

Following the proximity criterion, Asturias's forests appear as the main region of supply, followed (in this order) by Cantabria, the Basque Country,[11] and Navarra. There was also a significant group of endogenous timber pieces with undetermined origin, which was constituted by spare timber from Guarnizo shipyard (Fig. 9.2b). Each of these regions had a contractor who operated the felling, carving, and transport of timber by land and final delivery by boat: Andres Garcia Quiñones, António

[8] AGS, SMA, 621: November 15, 1771; AGS, SMA, 621: September 15, 1772; all these calculations are merely indicative.

[9] *Reglamentos de Maderas*

[10] Gautier, F. 1769. *Reglamento de maderas de Roble necesarias para fabricar un Navio de 70 Cañones*. Mss. San Lorenzo, 11 November 1769; AGS, MPD, 41, 033bis. Ubicación Anterior: SMA, 00342.

[11] sources of this group of timber are unclear about the specific provenance and just refer to the contractor, who was operating in both regions.

Francisco Quiñones, and Juan Gonzalez Pola, for Asturias; Francisco Caetano Iglesias, for Cantabria; *Real Compañia Guipuzcoana de Caracas* for Guipuzcoa and Navarra.[12] Oak, the predominant timber with 14,091 units, could be found from Asturias to Navarra and was, once again, mostly used for planking (4218 units), followed by framing elements, such as futtocks and beams, uncategorized pieces, and then a great variety of types (Table 9.1).[13] Beech (*Fagus sylvatica*) had a similar regional distribution and was used for planking, beams, and also came in as raw timber. Holm oak (*Quercus ilex*) was identified as coming from Cantabria, but its largest portion does not have any specific mention regarding the origin. It was used for axles of gun carriages and other unidentified applications Black poplar (*Populus nigra*), walnut (*Juglans regia*), alder (*Alnus glutinosa*), and ash (*Fraxinus excelsior*) came from Asturias and were sporadically delivered in small quantities. Except in the case of walnut planking, these types of timber arrived as unprocessed timber. Pyrenean pine has a low representation within the overall Northern Spain timber accounts, corresponding to only 2% (402 m^3). This supply is the result of technical experiments with the purpose of reducing dependency from Northern Europe imported pine[14] (Fig. 9.2b and Table 9.1).

The data indicates the secondary role of timber import through the Baltic trading networks, as these constitute 23% in terms of volume (total of 5394 m^3 along the 1771–1773 period), even if, in terms of unit quantities, Northern Europe timber corresponds to 64%, with 34,550 pieces (Fig. 9.2). This material is exclusively made out of pine, consisting of planking, the largest group of pieces, in 34,338 units,[15] 45 main masts, and 167 minor masts and spars[16] (Table 9.1), revealing the importation of highly specialized products. In a time of economical protectionism, the Maritime Departments would limit the acquisition of exogenous raw material to timber that could not be found in the Iberian Peninsula in abundance with the proper sizes, and which was strictly necessary to build vital and substantial parts of the vessels. That was the case of the pine species from Northern Europe, such as *Pinus sylvestris* which had long, wide and straight trunks, which made them especially suited for masts, spars, and planks (Aranda y Antón 1999).

This mass-produced timber served the European market (Astrom 1988), and Spain became a substantial importer, purchasing this material increasingly from the 1740s (Gallagher 2016; Reichert 2016). Spanish agents took part in the timber trade networks through supply contracts with the Navy, the so-called *Asientos.* By the time of the *Magdalena's* construction, Pedro Chone, a Bilbao resident, was the provider of masts, spars, and planking for the three Maritime Departments of Cartagena,

[12] references are the same used in the counting of northern Spain timber

[13] in order to facilitate the statistic study, the piece typologies were aggregated within main functional groups, in order to avoid an exhaustive list (ex.: first and second futtocks count together just as futtocks)

[14] AGS, SMA, 349: November 20, 1771; AGS, SMA, 349: July 25, 1772; AGS, SMA, 349: September 23, 1772; AGS, SMA, 349: November 14, 1772

[15] excluding 32 from the Pyrenees

[16] excluding 27 from the Pyrenees

Cadiz, and Ferrol.[17] Aided by representatives in Spain, the contractor operated from the Baltic ports of Saint Petersburg, Riga, and Danzig, negotiating with the local suppliers and coordinating the shipments through Dutch captains and merchant vessels, such as *urcas* and *galeotas.*[18] As the stocks seemed to be constantly running out of pine, the Navy sporadically sought alternative suppliers when the contractor was not able to fulfill the necessities in due time.[19]

According to STRO, there were 35 passages containing timber destined for Ferrol via the Danish Sound between the years 1770 and 1773. Only seven of these[20] can be matched to records in the TMC.[21] Possible reasons for this are that the timber may have been redirected or re-exported to another port, or that the wood was purchased by someone other than the Navy. After all, timber was also needed for general carpentry, private construction, and private shipbuilding. Indeed, six of the unmatched passages contained timber that was designated for shipbuilding, such as masts and spars, or accompanying products such as hemp or sailcloth.

Of the matched records, all were carried by Dutch captains, representing Ameland, Amsterdam, Hoorn, and Warns as homeports. Three of these passages originated from Danzig and four from Riga. Products brought from Danzig were fir deal (*fyrredehler*), thick planks (*bohler*), and unspecified wood products (*trævahre*). Products brought from Riga were boat-hook shafts (*baadshagestager),* balks (*bielker*), ordinary deals (*gemeenedehler* or *ord. dehler*), masts (*master*), spars (*spirrer* or *raaer*), and planks (*planker*). Only two shipments matched closely with the products and numbers given in both the TMC and STR. These discrepancies make it difficult to conclude how much Baltic timber noted in the STR was destined for the Spanish Navy. Out of 50 payment orders in the TMC for the department of Ferrol concerning the acquisition of timber within Europe between the years of 1770 and 1773, only six could be confirmed to concern timber that came directly from the Danish Sound (representing seven STR records). Only two other shipments were re-exported via Amsterdam, and thus, are not reflected in the STR. This suggests that the majority of the Navy's trade with the Baltic was direct by this time, rather than passing through a "middleman" port such as Amsterdam.

An important aspect which the Sound Toll Register corroborates is that the imported timber was never oak, or any of those pieces necessary for the framing

[17] AGS, SMA, 788, January 2, 1772

[18] AGS, SMA, 621: September 1, 1772; AGS, SMA, 621: May 29, 1773; AGS, SMA, 621: August 20, 1773; AGS, SMA, 788: January 2, 1772

[19] AGS, SMA, 350: May, 15, 1773; AGS, SMA, 621: November 16, 1771; AGS, SMA, 621: May 20, 1773.

[20] Sound Toll Registers Online viewed March 31, 2017: STR270070, September 5, 1770; STR257963, September 23, 1770; STR256454, October, 24, 1770; STR301893, August, 2, 1771; STR260730, August 2, 1771; ST260841, August 3, 1771; STR269696, September 14, 1772

[21] matches between the TMC an STR were found by looking for the captain, year, port of origin, port of destination and then at the transported products; the captain and the year are the most reliable elements for cross-referencing, since the products were categorized differently in the STR and the TMC, and sometimes show completely different numbers.

elements of the hull. Instead, they mostly consisted of spars for rigging and various sizes of pine planking, which were used in the final construction steps of a ship, such as upper hull planking, deck planking, and sacrificial outer planking.

The Caribbean supply corresponds to only 3% of the total volume with 1004 m^3 and 1674 pieces (Fig. 9.2). This timber had its origins in Cuba and Mexico, and its supply was locally operated by shipbuilding contractors of the arsenal of Havana, and then the Navy and Crown colonial officers would transfer part of this material to Spain, through the ships of the *Carrera de Indias,* among other goods in its cargoes, such as sugar, which was possible due the low volume of each shipment. Cadiz was the destination port of this route since 1717 and worked as redistribution hub, by sending material to Ferrol, as well as Cartagena.[22] Sometimes, the transport was made by charted private ships, which would deliver the material directly to Ferrol.[23]

The tropical timbers, such as guayacán (*Guaiacum*), cedro real (*Cedrela odorata*), chicharrón (*Terminalia eriostachya*), and sabicú (*Lysiloma latisiliqua*), are very hard, dense, and resistant types of material, particularly suited for the crafting of structural pieces and those which are subject to aggressive elements, such as constant friction and exposure to corrosion by shipworms such as *Teredo navalis* (Aranda y Antón 1992; Aranda y Antón 1999). Thus, the lists of deliveries contain cedrela futtocks, stringers, wales, and anchor strocks of undetermined tropical species, keels made of cedrela and chicharrón /sabicú, cederela top timbers, guayacán logs for further carving, chicharrón/ sabicú, and cedrela keelsons, among other typologies, and a vast group of undetermined typologies of guayacán pieces (Table 9.1).

Some 1771 and 1773 documents may contain the explanation for such small deliveries, as they mention that the Spanish arsenal's stocks were already well-supplied with Guayacán[24] due to the constant shipments and low use of this material and, therefore, new shipments should be suspended.[25]

3 Archaeology: Sampling the *Santa Maria Magdalena* Timber Assemblage

The remains of a vessel constitute the ultimate evidence of how ships were built (Steffy 2012). As mentioned above, the frigate *Magdalena* was built in the shipyards of Ferrol and sailed for about 37 years in the service of the Spanish Navy. During that time, the vessel benefited from repairs and adjustments that made her unique in many ways. *La Magdalena*'s unique features are a testimony to a specific

[22] AGS, SMA, 347: February 6, 1771

[23] AGS, SMA, 347: May 4, 1771; AGS, SMA, 347: August 24, 1771

[24] AGS, SMA, 347: July 19, 1771

[25] AGS, SMA, 350: June 4, 1773; AGS, SMA, 350: July 10, 1773

moment in naval history in which several countries were at war and were in direct competition for the expansion of their overseas power.

Also at this time, shipbuilding technology was shifting into the experimental. Shipwrights and shipbuilders were developing and testing building techniques using wood species other than oak and pine, which had been the woods of choice for hundreds of years. According to Enrique García–Torralba (García–Torralba Pérez 2011), the *Magdalena* was part of a test and therefore, built following specific procedures. Under the same geometric plans, four vessels were constructed in the shipyards of Cartagena and Ferrol: *Magdalena*, *Margarida, Marta,* and *Clara*. Despite sharing the same drawings and architecture, different wood species were employed allowing shipbuilders from the Spanish Navy to identify and analyze each prototype and use the most reliable as a model to replicate. In order to better understand the decisions made in the forest and in the shipyard prior to the construction of the *Magdalena*, the ForSEAdiscovery dive team undertook an archaeological campaign in Viveiro, Galicia.

Over the course of seven days in June 2015, the ForSEAdiscovery dive team removed 22 wood samples from the hull remains of the *Magdalena* at the bottom of the Viveiro Bay (Fig. 9.3a) in order to elucidate the circumstances of her construction – how she was built, with what kinds of wood, and respective provenance. In cases like the *Magdalena*, historical sources can be highly suggestive of where shipbuilders procured their timber, but taking timber samples from shipwrecks has several advantages to relying solely on the historical sources, even in well-documented cases like the timber supply for the arsenal of Ferrol. (1) Providing samples to wood scientists for further study is the only way to develop scientific methods of dendro-provenance so that they can be used in cases without historical documentation. (2) The scientific method allows for "proofs" of provenance that frequently challenge so-called reasonable assumptions as well as historical documents made in error. (3) Timber sampling campaigns permit an individual study of elements used in shipbuilding, such as wood types, scantlings, joinery and fixings used, as well as gathering the extent of the remains and their level of preservation and risk.

One of the outcomes of the ForSEAdiscovery project is to generate a set of protocols for the removal of wood samples from historic shipwrecks, and the fieldwork done at the *Magdalena* has been instrumental in this development. The sampling protocol defined that the impact on the remains of the vessel should be as reduced as possible. Therefore, it was only after mapping, sketching, positioning, and using other noninvasive recording methods were timbers finally sampled. To gain the most amount of provenance data while creating the least amount of damage to the shipwreck, certain timbers were targeted for sampling while others remained untouched. Elements likely to represent the original structure of the vessel, such as planks, beams, and frames, were preferred to minor elements which were frequently replaced and/or which would be unlikely to contain sufficient or reliable data for provenance.

In general, archaeological evidence of Iberian ships (Oertling 2001; Castro 2008) demonstrates a common practice of utilizing the parent tree's growth pattern for the required timber shape. This technique alone promises to help gain a better

Fig. 9.3 Sampling the *Magdalena* timber assemblage: (**a**) 2015 underwater archaeology campaign, (**b**) Sample of pine ceiling planking

understanding of the relationship between Iberian shipbuilding and forest management. For one, it demonstrates that shipbuilders were well aware of the properties of the wood they selected, and that this knowledge at the disposal of the shipbuilder to create more reliable vessels (although this is not to say that this knowledge was always actually put to use). For example, fast-grown deciduous oak was frequently used for vertical elements like frames, while slower grown oak could be used for horizontal elements. Because oak is ring-porous, each ring represents a potential breaking point, so the more rings a tree and its derivative timber have, the more vulnerable it is to splitting with vertical pressure, as would be experienced by frames and stanchions (Rich et al. 2020). Horizontal elements on the other hand do not experience the same kind of pressure against the cross-section. Therefore, to provide samples to wood scientists reliant on high numbers of annual growth rings (e.g., dendrochronology), planks were targeted over frames, the latter of which tended to represent the parent tree well, but were often only a couple decades old when felled. Figure 9.3b is a sample of ceiling planking that was converted from a slow-grown pine tree and preserves 146 annual growth rings, which made it an ideal candidate for wood provenance analyses. Another factor in its suitability for our study is that even after 200 years underwater, this wood sample is very well preserved with very few bore holes introduced by *Teredo navalis* and other xylophagic organisms that would increase the difficulty of taking accurate measurements of tree ring widths or of chemical composition.

Each of the 21 samples taken from the *Magdalena* was treated as an artifact. They were cleaned, measured, photographed, drawn, and entered into the ForSEAdiscovery database before being stored in fresh clean water and delivered to their destination – the wood science lab. The recording of each sample was performed with a tablet and stylus to produce detailed record sheets to hand over to the wood analysts along with the samples themselves, which are often destroyed over the course of analysis. These primary records are also retained in the database for studying the scantlings, tool marks, and joinery methods of sampled ship components, as well as the conditions of the wood when it was sampled, which may be useful for future conservation and site formation process analyses.

4 Wood Science: Aiming to Establish the Provenance of the Wood

Once the shipwreck samples arrived at the laboratory of dendrochronology of the University of Santiago de Compostela (Spain) a selection was made, setting aside the best preserved samples (i.e., showing the least number of galleries caused by *Teredo navalis*) to divide them into subsamples that would be used for organic and inorganic geochemical studies of wood composition and characterization. The main aim of the wood science team of the ForSEAdiscovery project is to develop reference methodologies and datasets to enable establishing the provenance of Iberian ship timbers. These comprise tree ring-based datasets (ring width, early-wood, latewood, vessel, and latewood density chronologies), stable strontium isotopic data, and data about the organic composition of different wood species in different areas. All these datasets have been developed for pine (*Pinus nigra* and *P. sylvestris*) and oak species (*Quercus robur, Q. petraea, Q. faginea*, and *Q. pyrenaica*) in key areas of the Iberian Peninsula that supplied timber for shipbuilding during the early modern period (Domínguez–Delmás et al. 2020). The techniques used for organic and inorganic wood characterization have been conducted in a smaller group of samples of the trees used for dendrochronology and wood anatomy. Once the reference datasets have been concluded, it has been possible to cross-check the shipwreck timbers with them in order to try and identify the origin of the wood. In this work, we present results of the dendrochronological analyses and preliminary data from infrared spectroscopy on the *Magdalena* shipwreck samples, research carried out at the University of Santiago de Compostela (USC, Spain).

4.1 Dendrochronology: Finding Out the Date and Provenance of the Wood Through Tree Rings

Samples from 21 different timber elements of the *Magdalena* shipwreck were sent to the laboratory of dendrochronology of the department of botany at the USC.

A preliminary inspection was carried out to determine the suitability of the samples for dendrochronological dating. Such samples should contain a sufficient number of tree rings to allow for sound statistical results (e.g., 80–100 tree rings). Exceptionally, timbers with as little as 30 tree rings could be researched to attempt cross-dating with other samples from the same structure, and thus all timbers with more than 30 tree rings were analyzed in this study. The transverse surface of the samples was cleaned with razor blades from the inner- to the outermost ring to perform a ring count and register the presence of pith and sapwood. This preliminary inspection also served to identify samples corresponding to the group of deciduous oaks (*Quercus* subg. *Quercus*), and chestnut timbers (*Castanea sativa*), as both present large earlywood vessels placed in a ring-porous disposition, although the deciduous oaks show large multi-seriate medullary rays that distinguish them from the chestnut. These characteristics make them distinguishable by the naked eye. The identification of other species was attempted through observation with an Olympus BX40 microscope of wood anatomical features on thin slices of the radial and tangential section of the wood and using the identification key proposed by García Esteban (2003). Ring width acquisition was done with a timetable measuring device (University of Vienna) coupled with PAST5 software (SCIEM).

Table 9.2 Results of species identification and tree ring analysis. Species: 1, *Quercus*subg. *Quercus*; 2, *Pinus sylvestris/nigra*; 3, *Castanea sativa*; 4, conifer (unidentified); pith: present (+1) / absent (–); bark edge (WK): present (+) / absent (–) / estimated; MRW: mean ring width (cm); σ: standard deviation (cm)

Sample number	Type of timber element	Species	Dendro code	N rings	Pith	Sapwood	Bark Edge	MRW	σ
MAG01-001W-02S	Frame at bow	1	MAG00011	47	–	0	–	0.68	0.24
MAG01-001W-03S	Frame at bow	1	MAG00012	82	–	0	–	1.43	0.49
MAG01-002W-01S	Ceiling plank at stern	2	MAG00020	100	+	0	–	2.14	1.34
MAG01-003W-01S	Ceiling plankat stern	2	MAG00030	146	–	66	–	1.28	0.36
MAG01-006W-01S	Frame at stern	2	MAG00041	35	+	0	–	2.90	0.78
MAG01-007W-01S	Frame at bow	1	MAG00050	216	–	28	WK?	0.67	0.41
MAG01-008W-01S	Frame at bow	1	MAG00061	67	–	0	–	1.56	0.82
MAG01-009W-01S	Frame at bow	1	MAG00070	49	+	0	–	2.33	0.71
MAG01-010W-01S	Frame at bow	1	MAG00080	144	+	0	–	1.16	0.46
MAG01-011W-01S	Frame at bow	1	MAG00090	78	–	0	–	1.63	0.65
MAG01-012W-01S	Frame at bow	1	MAG00100	49	–	6	–	2.65	0.87
MAG01-013W-01S	Frame at bow	1	MAG00110	125	–	38	–	0.88	0.50

MAG01-014W-01S	Framing element from bow	1	MAG00120	51	–	–	–	1.69	0.72
MAG01-015W-01S	Hull plank from bow	4	MAG00130	32	+	–	–	3.64	1.06
MAG01-016W-01S	Sacrificial hull planking		MAG00141	100	+	–	–	1.66	1.20
MAG01-017W-01S	Wedge sample of frame at stern	1	MAG00151	65	–	–	–	2.18	0.82
MAG01-018W-01S	Frame section	1	MAG00160	78	+	–	–	1.91	0.83
MAG01-019W-01S	Frame section	1	MAG00170	119	–	–	–	1.24	0.51
MAG01-021W-01S	Chiseled block samples from outer hull planking	1	MAG00180	79	–	–	–	1.04	0.19
MAG01-001W-01S	Frame at bow	1	–	Unknown	–	0	–	Severely damaged by *Teredonavalis*	
MAG01-004W-01S	Stringer at stern	3	–	20	+	0	–	Not suitable dendro	
MAG01-005W-01S	Wedge sample from oak frame at stern	1	–	8	–	0	–	Not suitable dendro	
MAG01-020W-01S	Frame section	1	–	28	+	0	–	Not suitable dendro	

4.1.1 Wood Identification and Dendrochronological Results

Fifteen samples were identified as deciduous oak (*Quercus* subg. *Quercus*), five as conifers (four of which are *Pinus sylvestris/nigra*), and one as chestnut (*Castanea sativa*) (Table 9.2). The oak samples MAG01-001W-01S, MAG01-005W-01S, and MAG01-020W-01S, as well as the chestnut sample MAG01-004W-01S were discarded for tree ring analysis, as they contained less than 30 tree rings (Table 9.2).

Cross-dating with oak and pine reference chronologies from Spain, central and northern Europe resulted in the absolute dating of three samples: MAG01-018W-01S (dated after 1667 C.E.), MAG01-019W-01S (after 1716 C.E.), and MAG01-021W-01S (after 1702 C.E.) with chronologies of *Q. petraea* of the north of Spain, being a *Q. petraea* composite chronology (made with 17 trees from Cantabria and 2 trees from Asturias, QUPE19MC) the one providing the best statistical results (Fig. 9.4). The provenance of these timbers is therefore some forests in the north of Spain (regions of Asturias, Cantabria or Basque Country), but the dendrochronological results do not allow to pinpoint an exact location. The absence of sapwood in the samples hamper estimating the felling date of the trees, hence the dates can only be presented as *terminus post quem* (dates after which the tree was cut). The tree ring series of those samples have been averaged into the object mean curve MAG3MC that spans the period 1590–1716. The rest of the samples did not produce statistically sound results between them nor with the reference chronologies, therefore their date and provenance remain uncertain (see also Chapter 1, Vol. 2 where the dendrochronological research on *Magdalena* is considered in the broader context of similar research on other Iberian vessels).

4.2 *Geochemical Fingerprinting of Magdalena Shipwreck: Relevance of the Initial FTIR Results*

Wood is a complex polymeric material composed by polysaccharides and lignin. These lignocellulosic macromolecules are responsible for most of the physical and chemical properties that result on differences between wood types (Hedges 1989). The variety of wood types is not only associated to the taxonomies and the environmental factors of the growing location, but also to decay factors associated with the storage environment, particularly for archaeological woods (Fritts 1976; Hedges 1989). The characterization of the molecular structure of wood chemistry allows detailed understanding of wood properties. Although considerable studies have been done using diverse types of techniques, still much more effort needs to be done to get an understanding on the preservation of the chemical composition of archaeological wood (Pandey 1999).

Fourier transform infrared spectroscopy (FTIR) is a widely used vibrational technique for wood analysis (Colom and Carrillo 2005; Traoré et al. 2016). Contrary to conventional chemical analysis, it has the advantage to be time efficient and does

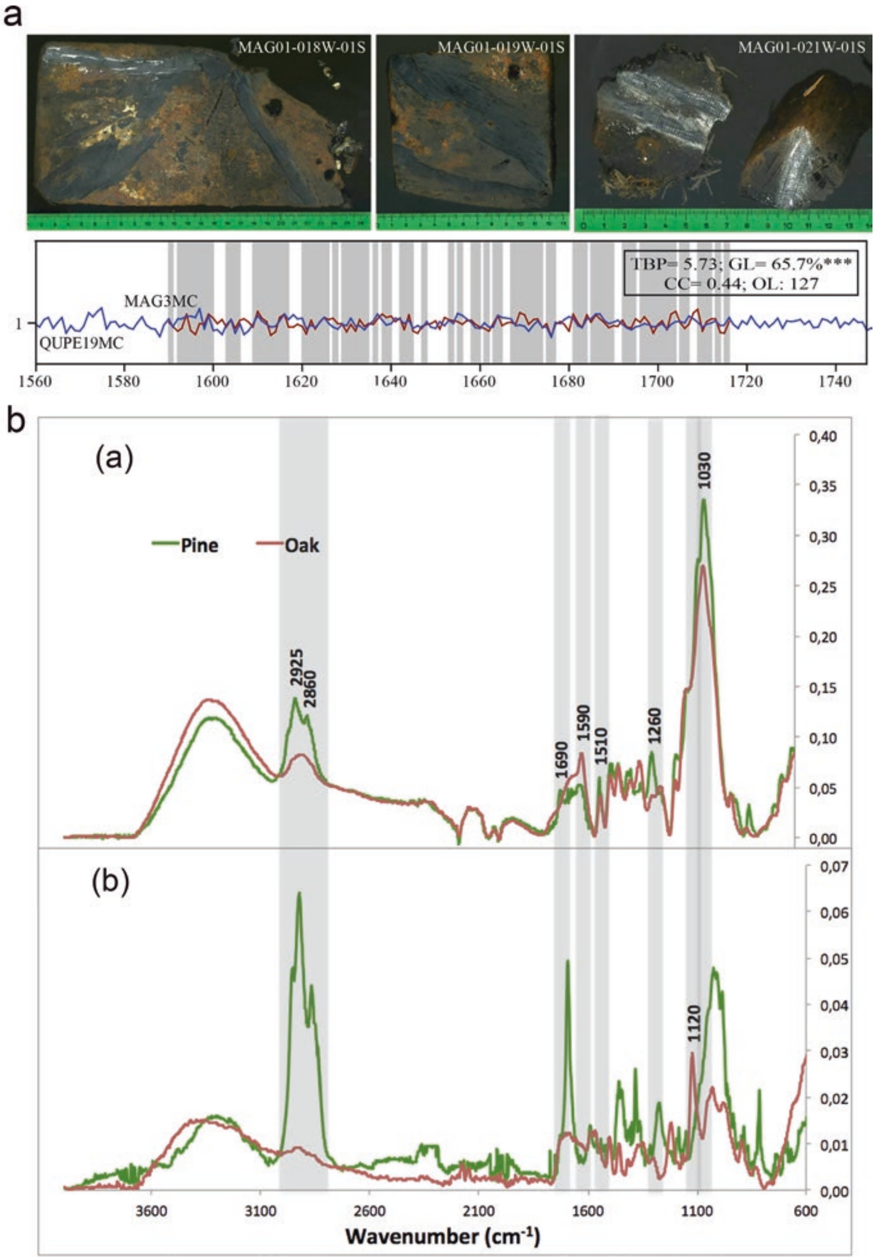


Fig. 9.4 (**a**) Oak samples from the *Magdalena* shipwreck dated by dendrochronology. Their tree ring series has been averaged into the mean curve MAG3MC, which dates against a *Quercus petraea* composite chronology (QUPE19MC). TBP: Student's *t*-value adapted according to Baillie and Pilcher (1973); asterisks represent the signification level of GL (***, $p < 0.001$); GL: percentage of parallel variation as defined by Eckstein and Bauch (1969), and indicated by the shaded background; CC correlation coefficient, OL overlap between the series; X-axis: calendar years, (**b**) Average (**a**) and standard deviation (**b**) spectra obtained by FTIR

not require sample destruction (an important aspect when analyzing archaeological artifacts). It has been used to differentiate between soft and hardwood, showing that softwood lignin is essentially composed by guaiacyl moieties, whereas hardwood lignin is composed by guaiacyl and syringyl moieties (Evans 1991; Colom and Carrillo 2005). FTIR has been more often used to evaluate archaeological wood in order to choose the appropriate conservation method. It is a useful technique to study chemical changes occurred during decay process undergone on ancient wooden artifacts. In this work, we applied FTIR on some wood fragments from *Magdalena* shipwreck timbers, in an attempt to evaluate the potential of this technique to allow the identification of the provenance of water-logged samples.

Four *Pinus* sp. (MAG02, MAG03, MAG15 and MAG16) and two *Quercus* sp. (MAG10 and MAG21) fragments were analyzed by FTIR. The samples were oven-dried for two weeks at 30 °C, and then the surfaces were cut in order to visualize tree rings. Measurements were performed on consecutive individual rings, from the outer part (recent rings) to the inner part (older rings) of each fragment. The FTIR–ART equipment used was an Agilent Cary 630 FTIR Spectrometer equipped with a single-reflection diamond crystal. The spectra were collected in the absorbance range from 4000 to 400 cm^{-1} over 100 scans per sample, at a resolution of 4 cm^{-1}. To get a first impression on the collected data, average and standard deviation spectra were calculated on the relative absorbance spectra. Average spectra reflect the dominant spectral bands, whereas the standard deviation indicates which are the largest relative variations (Traoré et al. 2016). For the purpose of this study, the samples were grouped according to the wood specie.

Figure 9.4 represents FTIR spectra of the two types of wood. The average spectra showed several peaks at identical bands for the two types of wood, but according to the relative peak intensity there were differences. Very high peaks with lower intensity for oak woods were recorded at band near 1030 cm^{-1}, which is attributed to C-O stretching in primary alcohol in cellulose (Popescu et al. 2007). Moderate absorption peaks were recorded near region assigned to symmetric CH_2 valence vibration at bands 2925 and 2860 cm^{-1} (Schwanninger et al. 2004). Several lower peaks were presented at region for bands absorption associated to aromatic molecular structures vibrations with lower intensity for pine woods at 1590 cm^{-1} and lower intensity for oak sample at 1690, 1510, and 1260 cm^{-1} (Colom and Carrillo 2005). The standard deviation spectra showed higher variability in pine wood than in oak wood. The largest variabilities in pine wood were highlighted at bands near 2925, 2860, 1690, and 1030 cm^{-1}. These bands are due to absorption respectively C-H stretch, carbonyl bond vibration in carboxylic structure and C-O bond vibrations, these bands are main peaks for terpenoid compounds (Faix and Böttcher 1992; Schwanninger et al. 2004). The highest variability in oak woods was presented at band near 1120 cm^{-1}, a related typical syringyl unit C-H bond vibrations (Popescu et al. 2007).

5 Conclusions

Despite the lack of data specifically related with the wood used in the construction of the *Magdalena,* written sources provide exhaustive information about the overall supply to the arsenal of Ferrol. These allow the characterization of the context within which the frigate was constructed, and therefore, give relevant clues for the archaeologists and wood scientists about the species, provenance and application of timber in the crafting of different ship elements. In fact, the results of the analysis of the historical documents indicate the high probability of the remaining framing elements of the hull and other elements placed below the waterline of containing a majority of Northern Spanish timber, particularly oak, followed by the other less-represented endogenous species, as well as a minor usage of tropical timber. On the other hand, aside from sacrificial planking, any Northern Europe pine timber that might have been used in the ship's construction, was most likely applied in the upper works and thus, has been destroyed through erosional and biodegradational processes over time in the archaeological wreck site. The documental evidence about the use of Pyrenean pine is a significant factor for the identification of the provenance of the extant pine elements.

To supplement the historical data and to provide a scientific basis for the relationship between forestry and shipbuilding practices in eighteenth-century Ferrol, an underwater archaeology campaign was enacted. A primary aim of the campaign was to remove wood samples from *La Magdalena*'s remaining hull timbers for dendroprovenance. In accordance with the protocols for in-situ ship timber sampling (Rich et al. 2018), specific timbers were targeted based the likelihood that they would be able to provide sufficient provenance data to justify their removal from the shipwreck assemblage. Qualifying factors included the timbers' function within the ship (i.e., original structural elements such as planks, frames, beams, etc.) and their condition (i.e., lowest levels of biogenic degradation). Timbers were fully recorded before sampling, and the 22 samples retrieved were treated as artifacts and equally recorded in great detail; these primary records are held in the ForSEAdiscovery database for further research into Iberian shipbuilding methods. The wood samples were then dispersed to partner laboratories for dendroprovenance.

Carrying out an appropriate sampling protocol is crucial for the success of dendrochronology. In the case of *La Magdalena* shipwreck, 11 out of the 21 samples retrieved presented almost 80 rings or more, and 3 of them could be absolutely dated, with a provenance in the regions of Asturias, Cantabria, or Basque Country in the north of Spain. This provenance is consistent with the information found in the historical archives about the origin of part of the wood supplying the Ferrol shipyard when *La Magdalena* was built. The lack of internal matches between more oak samples could indicate that the wood was sourced from different areas, which is also consistent with the archival information.

The preliminary results from the application of FTIR to *La Magdalena* shipwreck show the potential of using this technique to study water-logged woods. The use of the average and standard deviation spectra enables us to determine details about the chemistry of shipwreck timbers. From these results we can conclude that the combination of FTIR with powerful statistical methods is promising and may allow the identification of organic markers for the distinction between species and provenance of wood from shipwrecks.

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Chapter 10
The Manila Galleons in Perspective. Notes on the History and Archaeology of the Transpacific Trade

José Luis Gasch-Tomás

Abstract From 1565 to 1815, a commercial route known as the Manila Galleon connected the coasts of New Spain, in western Latin America, with the Philippine Islands under the control of the Spanish Crown. Galleons annually transported silver from the Americas to Manila, which was exchanged for Asian merchandise that was transported to the Americas. Recent studies about the Manila Galleon route are not only addressing economic and socio-cultural topics related to the transpacific trade, but a series of works referencing archaeological sources and material culture are also becoming significant. Therefore, remains of shipwrecks and Chinese porcelain are becoming as important as archival documents to write the history of the Manila galleons. This chapter offers some notes on the historiography and the archaeology of the Manila galleons. Then, it proposes common lines of research with the main aim, not to provide answers, but to propose a dialogue between historical and archaeological studies addressing the Manila galleons.

1 Introduction

The land is everywhere well shaded by trees of different kinds, and there are fruit trees which beautify it all the year round, both along the shore and inland, on the plains and in the mountains [...] *For this reason there is plenty of wood which is cut, sawn up, and then dragged to the rivers along which it is brought down. This wood is suitable for houses and buildings as well as for constructing large or small boats. There are in addition many stout, straight trees which are also light and pliant and can be used for making masts for ships or galleons. Thus, any sort of vessel may be fit with a mast made from a single trunk from one of these trees, without there being any need for splicing or fishing; or to make them up from different pieces. For the hulls of the ships, for keels, futtock- and top-timbers, and any other kinds of futtocks, breasthooks, puercas, transoms, llaves and rudders, all sorts of good timber can be*

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found easily. There is also good planking of quite suitable timber for the sides, decks, and upper works (de Morga 1972).

The author of these words is Antonio the Morga, who was assistant of the Spanish governor of the Philippines and judge (*oidor*) of Manila's courthouse (*Real Audiencia*) from 1594 to 1609. *The land* which De Morga refers to is the Philippine Islands. De Morga, who sent reports on the political and military state of the Philippines to the Spanish authorities of New Spain in the Americas, and to the king himself, noticed the presence of many varieties of wood that he considered suitable for building galleons and other ships.

From 1565 to 1815, a fleet made of two–four galleons and several minor vessels annually made a return trip from Acapulco to Manila crossing the Pacific Ocean. Although the Spaniards set foot on the Philippine Islands for the first time in 1521, when the archipelago was still known as the West Islands (*islas de Poniente*). In 1565–1571 they conquered the main island of the archipelago—Luzon—and established a permanent route across the ocean. In 1565, the expedition from New Spain to the Philippines headed by Miguel López de Legazpi and Andrés de Urdaneta found the Kuroshio current, which allowed the Spaniards to return to the Americas across the Pacific. In 1571, Spanish conquerors founded Manila in the mouth of the Pasig River and established a permanent commercial route between Manila and the western coast of New Spain, which was known as the Manila Galleon route (*galeón de Manila*) or the ship from China (*nao de China*). The Philippines was institutionally integrated into the viceroyalty of New Spain as a General Captaincy, which had their own governor and a courthouse, but was politically dependent upon the viceroy of New Spain. In 1593, the Spanish Crown regulated the commercial traffic of the Manila galleons. Several royal orders limited the annual round trip to two 300-ton galleons with a load capacity of 500,000 *pesos* in the journey from Acapulco to Manila and merchandise valued up to 250,000 *pesos* from Manila to Acapulco. Until the eighteenth century, the monarchy did not increase the permission allowed to transport silver and merchandise. Nonetheless, smuggling and contraband were common in the ports of Manila and Acapulco, like in other parts of the Spanish empire (Lytle Schurtz et al. 1992; Yuste López 1998).

The Manila Galleon route ended up transforming the economy of the Philippines and expanding global trade. The annual arrival of large quantities of American silver to exchange for Asian merchandise—above all Chinese silk and porcelain—alongside the monetization of part of the Philippine economy and the Spanish settlement of Manila, New Spanish and above all Chinese traders laid the foundations of long-term economic and sociocultural changes in Asia and the Americas. Transpacific trade became, alongside the Cape route trade via Africa and the Indian Ocean, the most important source of specie for China. Furthermore, the arrival of large quantities of Chinese silk and porcelain in the Americas transformed the taste and material culture of broad sectors of the colonial American population.

Literature on the Manila galleons is abundant since the early twentieth century. Topics including the role of silver in global trade, the organization of economies of scale around the Manila galleons, and the integration of Chinese silk into the fashion of Creole elites in the Americas, have all been at the center of historians' concerns. Furthermore, recent studies about the Manila Galleon route have not only addressed economic and sociocultural topics related to the transpacific trade, but also a body of research referencing archaeological sources and material culture is also becoming significant. Remains of shipwrecks and Chinese porcelain are becoming as important as archival documents to write the history of the Manila galleons. Archaeologists are using sources and approaches different from those of the historians in analyzing the Manila galleons. Because the research questions and fieldwork methods driving archaeologists are not the same as those of historians, it is worth attempting to build bridges between historical and archaeological studies of the Manila galleons. New questions and thus, a renewed knowledge of the Manila Galleon route could be born from the combination of archival, historical, and archaeological analyses. This chapter offers some notes on the historiography and the archaeology of the Manila galleons. Then, it proposes common lines of research, aiming not to give answers, but to propose a dialogue between historical and archaeological studies of the Manila galleons.

2 Historiography of the Manila Galleons

During the early modern era, Europeans made impositions of many types—political, economic, religious, social, artistic, etc.—and built connections between different civilizations of the world. The Manila galleons built one of those connections. This section offers a brief review of the main historiographical contributions to the history of the Manila galleons, while identifying existing lacunas and possible future research lines.

Several authors have written state-of-the-art of the Manila galleons in the last 20 years (Pérez Herrero 1989; García de los Arcos 1997; Elizalde Pérez-Grueso 2002). The following pages take those state-of-the-art into account and fill their most notable gaps, which are mostly recent contributions.

María Fernando García de los Arcos has pointed out that the most known historical works about the Manila galleons address trade (García de los Arcos 1997). Among the most significant books about the Manila Galleon route, there are synthetic works which offer an overview of the topic and were written before the so-called crisis of the old historiographical paradigms in the 1980s and early 1990s. Five of them are remarkable. Firstly, the most known is the classic *The Manila Galleon* by William L. Schurtz (Lytle Schurtz et al. 1992), which provided a before and after in the studies of the Manila galleons and had a decisive influence on later works. This was the first work that integrated a study on the main components of the transpacific trade—organization of journeys, merchandise, routes of the galleons, piracy, institutional and juridical aspects of trade, and so forth. Secondly, *Les Philippines et le Pacifique des Ibériques* by Pierre Chaunu (1966) is also remarkable, as it updated Schurtz's approach and framed the history of the Manila galleons within a more scientific and quantitative perspective, even though some of Chaunu's data were criticized later. Thirdly, *The Spanish Lake* by O. H. K. Spate (Spate 1979) is also significant. It not only deals with the economic and commercial dimension of the galleons, but also with the political and diplomatic history of the route. Fourthly, in the mid-1980s Carmen Yuste López, whose works on the Manila galleons are an inescapable reference, published her thesis, which was an update of the knowledge on the Manila galleons so far (Yuste López 1984). Fifthly, it is worth mentioning the works by María Lourdes Díaz-Trechuelo, who since the 1960s has worked on several aspects of the transpacific route from trade through urbanism and the architecture of Manila to the economy of the Philippines in the eighteenth century (Díaz-Trechuelo 1965, 1980).

There are several edited works of scientific and cultural encounters about the history of the Manila Galleons. In most of them the influence of cultural perspectives dominated the historical narratives of the Manila Galleon route. In light of this dominant perspective, it is worth mentioning the 1971 monograph in the series *Revista Artes de México* (number 171) devoted to the Manila galleons and the proceedings of topical conferences organized in Mexico City in 1989 (Barrón and Rodríguez-Ponga 1992). Other scientific and cultural encounters which resulted in the publication of works were *Extremo Oriente Ibérico. Investigaciones históricas: Metodología y Estado de la Cuestión*, which took place in 1988 at CSIC (Spain), and the First Mexican–Philippine Cultural Conference, which took place in Mexico City in 1996 (de Solano et al. 1990). Other edited volumes are *El Galeón del Pacífico* (Benítez et al. 1992) and the exhibition catalogue that took place at the *Hospital de los Venerables* of Seville, the Franz Mayer Museum of Mexico City and the Historical Museum of Acapulco in 2000. Alongside beautiful illustrations of Asian merchandise, that catalogue collects research papers on the Indies trade, the trade of the Philippines with Southeast Asia, the regulation of the Manila Galleon route, and the establishment of a direct commercial route between Manila and Spain in the eighteenth century (Araneta-Cruz et al. 1997).

Last but not least, it is worth stressing the importance of those works that have approached the history of the Manila galleons and the transpacific trade from recent historiographical trends. Among these contributions are the works by María Dolores Elizalde Pérez–Grueso, Carmen Yuste López, Salvador Bernabéu Albert, Carlos Martínez Shaw, Mariano Ardash Bonialian, and José Luis Gasch–Tomás. Elizalde Pérez–Grueso, whose expertise deals with the history of the Philippines, has coordinated an edited volume in which most scholars address the colonial impact of Spaniards in the Philippines from the sixteenth to the nineteenth centuries (Elizalde Pérez-Grueso 2002). Yuste López (2007) has largely worked on the commercial relations between the Philippines and New Spain during the early modern era. Her most recent work is an outstanding study of the trade of Mexican merchants in the Philippines via the Manila galleons during the eighteenth century. Bernabéu Albert and Martínez Shaw (Bernabéu Albert and Martínez Shaw 2013) have edited two volumes that gather the most recent contributions to the history of the Manila galleons, among which the combination of institutional, economic, and cultural perspectives has broken the traditional, rigid boundaries of the Manila galleons' historiography. The works by Ardash Bonialian (Ardash Bonialian 2012) and Gasch-Tomás (2014, 2019) have approached the history of the Manila galleons from a perspective which goes beyond the 'national' histories of the Philippines, Mexico, and Spain, by taking a global approach to their accounts.

The reference to the main works addressing the history of the Manila galleons provides a basis from which to dive more deeply into the content of the galleons' historiography. Given the geo-historical conditions of the transpacific route, the Manila galleons must be understood in a global framework of supply—trade—demand of Asian goods and American silver. The Manila galleons were a channel of exchange of Asian merchandise for American silver, which connected Asia, particularly China, with the Americas and other areas of the Atlantic World, as some of the Asian merchandise was re-exported from New Spain to Europe via the Atlantic. Taking this scheme as a reference, it is worth pointing out the main issues that have been at the center of historians' analyses.

The discovery and conquest of the Philippines is one of the most common subjects of historians studying the history of the Manila galleons. Apart from the classic literature, which generally emphasizes the agency of "great" conquerors, missionaries, and pious works (García-Abasolo 1982; Boxer 1984), there have also been works addressing the agency of the conquered during and after the conquest of the Philippines (Phelan 2012). From these newer approaches, it becomes clear that the expansion of Iberians, and later Dutch and English in Southeast Asia, converted Manila into an *entrepôt* in which the Chinese—so-called *sangleyes* by Spaniards and Portuguese—played an essential role in the history of the Manila Galleon trade alongside Spanish and American Creole missionaries and merchants (Clossey 2006). Furthermore, there are works that highlight the maritime dynamics existing in Southeast Asia before the arrival of Europeans, instead of the role of Europeans in the making of the history of Southeast Asia in the sixteenth and seventeenth centuries (Hamashita 2013). Following in a more traditional vein is the literature that addresses the history of piracy in the area around the Philippines and in the greater Pacific, which have mostly focused on English and Dutch piracy (Martínez del Río de Redo 1971).

There is much published information about the Philippine trade in the early modern era. To the east of the Philippines, Manila kept commercial contact with China for silk, porcelain, fans, and jewelry, among other products; Japan for folding screens and furniture; Indonesia for pepper, clove, and nutmeg; Siam for the resin, benzoin, used in incense and perfume; Burma for amphorae; Ceylon for cinnamon; India for cotton fabrics; and Persia for carpets. Chinese, Portuguese, and Dutch ships were the main conduits through which goods were transported and arrived at the port of Manila, often illegally, from other Asian markets. The institutional organization that articulated the loading and unloading of merchandise coming from other Asian ports to Manila and then shipped to New Spain is also well known (Lytle Schurtz et al. 1992), although there are no monographs on such important institutions as the Distribution Committee (*Junta de Repartimiento*) and the Valuation Committee (*Junta de Tasación*) of trade. When traveling eastward, the Manila galleons needed from 4 to 6 months to cross the Pacific to reach New Spain. Although the galleons could stop over at the Maluku Islands and the port of San Blas, in north-western New Spain (Pinzón Ríos 2014), the arrival port at the

Americas was Acapulco. The harbor movement and organization of Acapulco's annual commercial fair has been recently studied in relation to contraband and smuggling (Sales Colín 1997; Gasch-Tomás 2015).

One of the most important issues related to the Manila Galleon trade, which has been recently addressed by economic historians, is that of silver as the *raison d'être* of transpacific trade. Alongside the role of the Chinese fiscal system's demand for silver, which was one of the most important driving forces of global trade in the early modern era (Von Glahn 1996), historians are studying the importation of silver in Asia across the Pacific Ocean by relating, on the one hand, the unfavorable trade balance of Europe and the Americas with respect to China, and, on the other, the role of silver in economic, social, demographic, and ecological connections during the rise of global economy from the sixteenth century onward (Flynn and Giraldez 1995).

What happened with the Asian merchandise transported by the Manila galleons after it arrived in Acapulco? Since the 1980s, many historians have worked on the history of consumption and demand from an economic or cultural (or both) perspective. Some of the main transformations during the transition from the early modern to the modern era in the Atlantic World, such as the expansion of labor markets and the monetization of the economy, were related to changes in demand. The import of extra European goods, among them Chinese silk and porcelain, played a fundamental role in those changes. Recent studies have discovered that Asian goods, especially Chinese silk and porcelain, transformed the taste and fashion of American Creoles (Armella de Aspe 1992; Ardash Bonialian 2012, 2014), and additionally, that the Americas became a pioneer space in the Atlantic world for the commoditization of these goods (Gasch-Tomás 2014, 2019; Krahe 2016).

Furthermore, among the most recent and path-breaking studies are those who are dealing with the construction of the galleons which made the journey across the Pacific Ocean. Most of the Manila galleons were built in the Philippines, especially at the port of Manila–Cavite. In fact, shipbuilding became the most important industry in the early modern Philippines. Merchants, financers, colonial institutions, and large numbers of indigenous workers depended upon this activity. Contemporary sources to the time in which the galleons sailed suggest two main reasons why shipbuilding of the Manila galleons was a more productive enterprise than shipbuilding of Atlantic fleets. The first reason has to do with the exploitation of Philippine labor, which strengthened the Manila shipyards in relation to those in the Iberian Basque Country, where the main Iberian shipyards were located. The second reason has to do with the quality of wood exploited from tree species in the Philippines. According to various historical documents and contemporary botanical research, the varieties of Philippine timber—*tanguile*, *maria*, *guijo*, *lauan*, and *banaba*—were superior for shipbuilding because they were more durable and more abundant than what was available in Europe, which was mostly oak and pine (Peterson 2014; Wing 2015).

Studies of the Manila galleons are far from being exhausted. Given the trajectory of recent historiography, which has changed course to implement a global perspective, recent works point to an increasing interest in the combination of sources written in different languages—Spanish, Chinese, Japanese—which more and more experts are able to read. The result is the production of studies that better gauge the actual trans-“national” character of many early modern historical processes, of which the Manila galleons are one of the clearest example (Tremml-Werner 2015).

3 Archaeology of the Manila Galleons

Unfortunately, the archaeological studies of the Manila galleons have not developed as much as their histories. Apart from the few excavated underwater sites and several studies of the material culture transported in the galleons, especially Chinese porcelain and to a lesser extent Chinese silk and Japanese furniture, experts have undertaken few archaeological researches of the Manila galleons.

Roberto Junco is a notable exception and one of the pioneers of the Manila galleons archaeology. The following pages are partly based on his research and contributions.

So far, there are six Manila galleons’ sites which have been intervened (Junco 2010):

A. *San Agustín*. This ship wrecked in Drakes Bay, California, in 1595. It has not been excavated, but a collection of porcelain carried by the ship has been studied.
B. *Nuestra Señora de la Concepción*. This galleon, which sank in 1638, was located by treasure hunters. Ceramic containers, a collection of gold objects, and a silver coin are among the found objects.
C. *Santa Margarita*. The ship wrecked in 1601 in the Mariana Islands. Although the company IOTA Partners intervened the site and recovered pieces of ivory, porcelain, and gemstones, there is no published information about the intervention.
D. *Nuestra Señora del Pilar*. This galleon wrecked in the island of Guam in 1690. It was found and intervened by treasure hunters, who supposedly have only found 36 silver coins.
E. *San Diego*. This galleon sank off near Manila in 1600. Many objects have been recovered from this wreck—porcelain, sword guards, a crucifix, an astrolabe, a compass, and gold rings.
F. Beewax galleon in Oregon. This late seventeenth- or early eighteenth-century galleon, which wrecked near present day Nehalem, Oregon, has been excavated by the Service of Natural Resources in Washington State. Wax blocks and porcelain are the main objects recovered.
G. The Manila galleon in Baja California. This late sixteenth-century wreck located in the Pacific coast of Baja California has been excavated by National Institute of Anthropology and History (*Instituto Nacional de Antropología e Historia*) of Mexico. Among the objects recovered, there were coins, blocks of wax, and porcelain.

As already mentioned, a part of the goods transported by the Manila galleons did not end up in American territories but were re-exported to Europe in Atlantic fleets.

It is worth pointing out other ships, which were not Manila galleons, give information about the Manila Galleon route because they carried Asian merchandise which came from Manila. Among them, there are the *Golden Hind*, which had been commanded by Francis Drake, who attacked several Manila galleons in the Pacific and sank off the Drake's Bay in 1579; the *Witte Leeuw*, which was a Dutch ship that sank off near St. Helena, in the Atlantic Ocean, in 1613, and had Chinese porcelain among its merchandise; the *Nuestra Señora de Atocha*, which wrecked near Florida in 1622 and also carried Chinese porcelain; the *Nuestra Señora de la Limpia y Pura Concepción*, which got lost in Santo Domingo in 1622 and carried Kraak porcelain; the *San José y las Ánimas*, which sank off the Florida Keys in 1715 with Chinese porcelain from the Kanxi period; and the *Hatcher junk*, a Chinese junk that got lost in the 1640s in the South China Sea (Kuwayama 1997).

Apart from the galleons in Oregon and Baja California, which have been not historically identified yet, the rest of sites have not been archeologically intervened by professional teams with scientific methods.

The most significant production center of export ceramic in China was located in Jingdezhen—southeast of China—since the eleventh century. Later, in times of the Ch'ing dynasty, the emperors established in Jingdezhen an "imperial factory," which developed driven by the demand of the imperial court, Chinese noble elites, and, over time, the elites of Asian empires from Safavid Persia, Siam, and Japan. Chinese artisan not only decorated ceramics with typically Chinese motifs, which influenced the taste of other elites of the world, but also adapted decoration to the taste of foreign elites (Finlay 1998; Gerritsen 2012). An essential technological change took place when Chinese craftsmen were able to increase the temperature when firing ceramics, to the extent of producing porcelain. By adding kaolin's aluminium oxide, they could fire ceramic at 1300 °C. At that temperature, kaolin and ceramic melt and vitrify, which results in a new, whiter and stronger product—porcelain. Another innovation consisted in decorating potteries with blue coming from cobalt oxide, which applied to the object along with a non-color glazing and fired at high temperature, created a sort of discontinuity between white and blue. The result was one of the most global products so far, which circulated across markets of Asia, Europe and, from 1565 onwards, the Americas. In fact, Manila and the Manila galleons became essential conduits through which Chinese porcelain reached elites' houses from Mexico City, Lima, and Havana, among other big American cities (Canepa 2012).

Blue and white porcelain was the most common earthenware carried by the Manila galleons, but it was not the only type. There were also *blanc de Chine* ("white from China"), which was a ceramic whose only decoration was the white of pottery's surface and had a great reception in New Spain during the seventeenth century; *famille vert* or "green family," in which green dominated and was very successful in the Americas and Europe in the last third of the eighteenth century; Chinese *imari*, whose decoration was made of non-glazed blue and several enameled colors; and *famille rose* or "pink family," whose pink color came from the pigment known as purple of Cassius, which became common in Chinese production of porcelain during the eighteenth century. Ceramics and porcelains of these types decorated and contained such perishables as chocolate, wine, fruits, and spices, among others, in the houses of the richest of colonial Latin America (Curiel 2007; Bonta de la Pezuela 2008). The impact of Chinese ceramic and porcelain in New Spain was such that a notable industry of Chinese-like ceramic developed in the Americas, being Puebla de los Ángeles, in New Spain, the main imitation center of Chinese earthenware (Casanovas 2007).

Chinese ceramic and porcelain transported by the Manila galleons across the Pacific Ocean have been found in different areas of New Spain. Land archaeological sites and shipwrecks are the most important sources of Chinese porcelains and ceramics for recent and current archaeological studies. Archaeologists have identified Chinese porcelain in several sites at Puebla de los Ángeles and Mexico City, which are dated in the seventeenth and eighteenth centuries. In Puebla de los Ángeles, the most notable archaeological area where archaeologists have found, dated, registered, and analyzed Chinese porcelain and Chinese-like ceramics, is the so-called Potters' Quarter, which was articulated by dozens of pottery workshops (Lister and Lister 1984; Kuwayama 1997). In Mexico City, the presence of Chinese porcelain have been identified in several archaeological sites of the City (Nebot García 1970; Fournier García 1990). Moreover, there are many other archaeological places of present-day Mexico from which experts have recovered porcelain and ceramic produced in China, which shows the extent to which Acapulco and Mexico City were redistribution centers of these goods to other areas of the viceroyalty of New Spain, and how strong the demand for these products was. Among those places, are Huejotzingo, Cuernavaca, Otumba Valley, Oaxaca, Mérida, Veracruz, Michoacán, Pátzcuaro, Zacatecas, Rio Chiquito in Guerrero, Santa Fe in New Mexico, USA, and Antigua Guatemala, Guatemala (Junco and Fournier 2008). Regarding the underwater recoveries from sunken galleons, the abovementioned shipwrecks, most especially those at the Drake's Bay, are a source of Chinese porcelain bottles, jars, cups, bowls, plates, jugs, and vases, whose study has allowed creating typologies of Chinese porcelains' decoration (Kuwayama 1997). Last, it is worth pointing out that Chinese porcelain took part of royal collections of European Crowns' courts, which served as spreading space of the taste for the Manila galleons' products (Alfonso Mola and Martínez Shaw 2003).

4 Collaboration Between Historians and Archaeologists: The Future of the Manila Galleons

Junco has proposed some research lines in which the archaeology of the Manila galleons might go forward. Among them, there is the investigation of the shipbuilding of Manila galleons, research on the life on board using material culture, and comparative analysis of materials found in shipwrecks and in land archaeological sites (Junco 2010). I am proposing some lines in which the combination of historical and archaeological work might push forward our knowledge of the Manila galleons.

The first way to put in dialogue the work of historians and archaeologists lies in the possibility to come up questions which are of the interest for both fieldworks. The history of shipbuilding is actually the most effective way in which archaeologists and historians might work. Recently, interdisciplinary works which combine history and underwater archaeology dealing with shipbuilding in the early modern era have been developed by ForSEAdiscovery. ForSEAdiscovery is the first international research project financed by the European Union which addresses early modern shipbuilding. Alongside coping with the supply of timber resources for Iberian shipbuilding from the sixteenth to eighteenth centuries, the researchers of ForSEAdiscovery have integrated archaeological, archival, and dendrochronological methods to shed light on early modern shipbuilding techniques in Spain and Portugal (Crespo Solana 2016). The combination of archival sources and archaeological excavations might also result in studies of shipbuilding techniques of the Manila galleons. A comparison between the information of shipbuilding techniques and wood species—for instance, that of treatises and reports such as that of the captain Sebastián Pineda (1619), in which he collected the most important varieties of Philippine timber apt to shipbuilding—and timber samples taken from shipwreck sites, whose geographic origins and properties can be analyzed, could be a priority research line and shed much light on the history of shipbuilding in Manila.

Another research line between archaeologists and historians who study the Manila Galleon route might deepen the work already done in such shipwrecks as that of the Manila galleon in Baja California. In the case of this shipwreck, the combination of maritime history, the history of trade, and underwater archaeology has allowed to propose the galleon *San Felipe*, which sank off in 1576, as the most plausible hypothesis to historically identify this wreck (von der Porten 2010). Further interdisciplinary work between experts on early modern shipbuilding, historians of the transpacific trade, and wood scientist able to detect the geographic origin of timber, might be a great leap forward in the knowledge of the commercial route that for more than 200 years connected Asia and the Americas.

Connected to the previous line, another line of work dealing with the Manila galleons could benefit from advances in new technologies. Recently, approaches based on a geographically integrated perspective, which takes into account changes in spatiotemporal variables, are allowing connecting local and global historical dynamics into the same framework (Owens 2007). These approaches are mostly making use of such tools as geographic information systems (GIS). The application of GIS not only to the geo-localization of sunken galleons but also to the geo-localization—and changes in that geo-localization—of such essential factors in shipbuilding as wood species and the geographic origin of shipbuilders and labor, as well as to the origin of the material culture found in sites, may shed light on how spatiotemporal factors influenced the historical dynamics associated to the Manila galleons.

Historians and archaeologists, especially from Europe and Mexico, have started to collaborate in the studying shipbuilding of Atlantic fleets and galleons by using approaches, methods, and techniques from different fields. Unfortunately, historical and archaeological studies that integrate shipbuilding and trade in the Pacific and the Atlantic Oceans have rarely been undertaken. Similar collaborations might open lines of comparison between shipbuilding techniques, technical applications, and the gap between the original projected plans and the actual construction of galleons in the Atlantic and in the Pacific. This surely would contribute to offer a more complete picture of the political economy and the relative use of natural resources in the Spanish Empire. Studies that compare shipbuilding, the durability of materials and the management of labor, wood, and other basic shipbuilding materials, would allow further inferences about the economic history and the history of technology in the pre-industrial world. However, this task only could be carried out by developing spaces of collaboration between specialists of different areas of expertise and, given the vastness of the early modern Spanish empire, from different countries.

Finally, archaeologists and historians concerned with the main product transported by the Manila galleons—Chinese porcelain—have come up similar questions. If robust interdisciplinary work were conducted, the conclusions reached so far might go beyond the boundaries of the two disciplines—archaeology and history. One of the main contributions might be reached regarding one of the questions which have not been clarified yet, neither from archaeological nor from historical researches. This question is the extent of the spread of purchase and use of Chinese porcelain among the populations of the Americas—in other words, the extent to which sectors who did not belong to the colonial elites, i.e., such sectors as indigenous and *mestizo* (mixed-race) populations, purchased Chinese porcelain in colonial Latin America. A positive answer to this question might shed much light on the transformations of the supposedly rigid race and social hierarchy of the colonial Americas during the early modern era. Urban archaeological studies in New Spain, which have registered Chinese porcelain, might help to determine the extent to which earthenware and porcelain from the Manila galleons were present in quarters and city areas where indigenous and *mestizos*, of which historical sources are scarce, lived.

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Chapter 11
Ploughing Through Global Seas: Maritime Routes and Hydrographic Knowledge in the Eighteenth-Century Spanish Navy

Pablo Ortega-del-Cerro

Abstract During the second half of the eighteenth century, the Spanish navy made a great effort to elaborate modern hydrographical knowledge and develop new maritime routes. The global context, imperial strategy, trade, scientific advances, and shipbuilding techniques led to forge a new network of communication for the Spanish monarchy. Beyond the classical Atlantic connections, the navy got information on courses to Africa, Asia, North and South America, and Oceania. The objective of this work is to analyze the making of this knowledge and the development of the increasing number and variety of maritime routes. The chapter is organized in three sections by proposing different stages of this problem. Each part tries to study the aims, problems, needs, and achievements that the navy had to deal with.

1 Introduction

In 1809, the Spanish navy showed clear signs of crisis and decadence. The number of warships decreased, the budget for the Ministry fell down and its staff had to join the Peninsular War against the French army (Martínez-Valverde 1974; Martínez Ruiz 2003; Lebrón García 2009). Nevertheless, this year *Memories on Astronomical Observation Made by Spanish Navigators* (Espinosa 1809) was published. This book was surfaced from the Hydrographic Direction of the Navy—it also was so-called Hydrographic Deposit—and was the culmination of all the efforts carried out by the navy for 60 years. It constituted a useful and updated guide to sail around the world and summarized the main achievements on hydrography, navigation, astronomy, geography, and physic. Beyond its technical nature, the book had great relevance for Spanish society; it symbolized a decisive step forward in maritime knowledge and modernized definitively scientific data for warfare and trade

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navigations (Salazar 1810). The repercussion of this book led to publishing a summarized and educational version one year later (Fernández Navarrete 1810).

The Hydrographic Direction of the Navy was formally created in 1797 (Chaín-Navarro and Sánchez-Baena 2011; González 2016). It was the main center for research on navigation and its objective was the promotion of hydrography—according to the Spanish Dictionary, "the art that deals with the description of the seas and the way of making nautical charts, navigating and driving ships on long voyages." During the eighteenth century, maritime knowledge change; the art of navigating became the science of sailing, so it was necessary to improve information about winds, sea currents, coasts, latitude, longitude, the calculation of distances, or the measurement of speed (Sellés 1992, 2000; González del Piñal Jurado 2006). The navy needed a specific institution to analyze and keep all the documents generated by the maritime expeditions and progress in these issues (Del Campo Hernán 2016). Since then, the Hydrographic Direction gathered and examined maritime courses, charts, calculations of latitudes and longitudes, economic reports, and geographic investigations. There was little doubt about the usefulness of this enterprise; trade routes and warships' commissions benefited, and Spanish fleets could practice modern sailing.

Further, this qualitative improvement in hydrographical knowledge, another fact equally important must be remarked. During the second half of the eighteenth century, the Spanish monarchy multiplied the maritime routes. The courses and ports for commerce and the navy increased exponentially because the empire had to adapt to a new global context (Davids 2020). It was not only necessary to communicate the Iberian Peninsula with the Caribbean, as had been done through the fleet and galleon model, but also with the South Atlantic, Chile, Peru, California, Asia, and Africa. An urgent task was to create safe, fast, and efficient routes with all these points. This problem was clearly exposed by the Count of Floridablanca—the Prime Minister and Secretary of State—when he made a report on the main needs of the monarchy in 1787: "In such a way that the navy has surveyed the Strait of Magellan, it must progressively recognise all the coasts of the vast dominions of His Majesty in the four parts of the world. It is necessary to discover shorter and safer routes for navigation to the most distant and less frequented countries. Every year the Secretary of the State for the Navy will propose at least one expedition of this type" (Muriel 1839).

The objective of this chapter is to analyze the creation of hydrographic knowledge and the development of an increasing number and variety of maritime routes during the second half of the eighteenth century and the first decade of the nineteenth century. The work examines how the navy collected data on navigations, undertook scientific research, and created and improved maritime routes—not only for the empire's areas but also other regions of the world. The study tries to remark the main achievements and focuses on how this information was managed. In order to observe the progress and expansion of the routes, this chapter proposes three phases of the making of this knowledge and contextualizes the problem within a global context and other issues, such as empire strategy, trade, naval construction, or communications.

During the first stage, between 1748 and 1783, the classic communication system of the Spanish monarchy changed and new paths were opened to different parts of the globe; the second phase lasted throughout the 1780s and 1790s when numerous inquiries were developed and real advances in hydrography were made; and during the final stage, between 1797 and 1815, the Hydrographic Direction did analysis works to create a new corpus of maritime knowledge and published the main results. The sources analyzed in this chapter come from the original publications of the Hydrographic Direction, the historical archive of this institution—currently in the Archive of the Naval Museum of Madrid—and a wide range of documents generated in the expeditions of the navy during the second half of the eighteenth century—these sources are in the General Archive of Simancas and the General Archive of the Navy (Alvarez Pinedo and Tavera 2005).

Although many works deal with navigation, astronomy, and expeditions of the eighteenth-century Spanish navy—a long list of references is provided throughout the chapter—, there are still open problems. This chapter attempts to offer an innovative overview map of all the routes created during the second half of this century, and at the same time seeks to underline the multidisciplinary nature of the commissions undertaken. Hydrographic inquiries went hand in hand with reports of another nature, such as commerce, politics, or economics. Furthermore, it is necessary to underline the importance of the global context in this issue; the growing dependencies and rivalries around the world conditioned and, in fact, explain this phenomenon. Ultimately, this chapter seeks to analyze how the Spanish monarchy created multiple naval "tentacles" in a more interconnected and interdependent world.

2 Reviewing Old Connection and Opening New Routes for the Empire (1748–1783)

From the sixteenth century, Spanish trade was organized around the *flotas y galeones*—fleets and gallons. Each year, two convoys set sail from Seville—or Cádiz since 1717—, one to Veracruz and another one to Portobello and Cartagena de Indias; later both fleets met in Havana and returned to the Iberian Peninsula. The goods reached the rest of the empire through secondary routes, the galleon of Manila to the Philippines and Asia across the Pacific, and the South Seas navy to Peru. The course between Spain and the Caribbean was the main axis of communication for the monarchy, so a specific squadron of the navy had to defend it. At the beginning of the eighteenth century, a new dynasty came to the Spanish throne and important reforms were carried out. The old system of war-fleets was replaced by a new navy, the *Real Armada*, a unified and centralized model controlled by the Secretary of State for the Navy. Nevertheless, the new navy still used the classical routes. During the first third of the century, most expeditions of the *Armada* to the Indies went to the Caribbean, and only three missions went to Buenos Aires to transport troops and information. This means that the projection and scope of the *Real Armada* was fundamentally North Atlantic.

Throughout the first half of the eighteenth century, there were several attempts to promote trade and improve communications with the empire. However, major changes came after 1750. The Jenkin's Ear War (1739–1748) was decisive because evinced that the old system was obsolete and because a new model began to emerge. The fleets and galleons had shown many problems in the eighteenth century since the enemies knew the route and vessels were an easy target to attack. In order to ensure trade in wartime, the King allowed loose boats—*navíos sueltos*, that is, without forming a convoy—to navigate. In this way, the trip would be faster, and ships could more easily escape from an assault (García-Baquero González 1988).

This new model of loose ships became widespread and provoked the number and directions of navigations multiplied. It was necessary to improve the knowledge on coasts, winds, sea currents, latitudes, longitudes, or instruments, and the *Real Armada* assumed this objective (Sellés 2000). This challenge had to be addressed through a new concept of expeditions, as warships should assume multiple competencies. An important precedent was the French geodesic commission to Peru (1735–1744). The purpose of this expedition was to measure the equator and determine the size of the Earth's arc (Gonzalez de Posada 2005). Two young Spanish naval officers—Jorge Juan and Antonio de Ulloa—joined and became forerunners for future naval expeditions. In addition to scientific topics, they made relevant inquiries about navigation, economics, and politics, which were published some years later.

The Spanish monarchy was aware of the new needs and undertook a different policy for expeditions. An urgent task was to review the classic maritime routes and improve navigation to the Caribbean Sea, the South Atlantic, and Peru. This was a common challenge for the European monarchies of this period since increasing trade and expanding areas of rivalry caused the Crowns to seek advances in astronomy and other useful sciences to renew nautical studies. In Spain, the Astronomical Observatory of the Navy was founded in 1752 and Jorge Juan published in 1757 *Navigation Compendium for the use of Midshipmen—Compendio de navegación para el uso de los cavalleros Guardias Marinas*—, a modern guide in which new hydrographic knowledge was include.

This spirit was imposed not only in scientific missions but in all expeditions of the navy. For instance, in 1749 the commander of the frigate *Margarita*, Francisco de Bances, wrote his navigation diary from Havana to Cádiz.[1] This was the most common route for Spanish vessels and was well known, although it was still too rudimentary. The trip began in Havana, continued to Bermuda and Santa Marta, and then to Cape San Vicente. The latitude was calculated correctly but the longitude was very elementary—the Spanish navigators used at that time the meridian of Tenerife. Some years later, in 1753, the pilot and naval lieutenant Manuel de Echevalar published a work entitled *Exact and useful instruction on navigations to Septentrional America.*[2] This book is interesting because described the courses to

[1] Archivo General de Simancas (AGS), Secretaría de Marina (SMA), leg. 401, exp. 12.

[2] Archivo Museo Naval (AMN), 192, Ms. 320.

various parts of the Caribbean—Havana, Veracruz, Puerto Rico, and Barlovento—in summer and winter. According to this publication, navigation was guided by ocean currents, winds, and some landmarks, such as islands, but there was no information on latitudes or longitudes. This makes clear that by 1750 most sailors still navigated in a hazardous way.

Along the 1750s new ports of Spain were included in the routes of the navy. Ferrol became an essential point for military expeditions, so it was necessary to adapt the nautical courses.[3] Between 1735 and 1748 only six navigations of the navy left from Ferrol, but between 1749 and 1763 there were 12. The navy made a great effort to connect Ferrol with the main existing routes, especially with Cartagena de Indias, Havana, and Veracruz. In this Galician city, one of the most important shipyards of the monarchy was built—first in La Graña and later in Esteiro. Many recently launched ships left this port. For example, between 1752 and 1757, 12 ships-of-line were built there; they were so-called the *Twelve Apostles* and followed the English system of construction proposed by Jorge Juan, a much cheaper and standardized model than the previous one (Serrano Ruiz Calderón 2019). During the first half of the eighteenth century, Spanish shipyards were built according to Gaztañeta's model, whose ships were efficient but expensive to build and their lifespan was too short.

Beyond North Atlantic connections, other maritime routes were known but information about them was precarious. Possibly the most important was the course to the South Seas through Cape Horn. The traditional communication was made through the galleons from Portobello-Panama, but the new context required changes. In 1748 the ships-of-line *Castilla* and *Europa* were sent to Lima to defend these seas, and in 1760 the frigate *Hermiona* carried artillery and troops. Both missions crossed Cape Horn successfully, although the navigation was very dangerous. Another expedition was made in 1760; lieutenant Arostegui sailed the frigate *Liebre*—built in 1755 in Cádiz following the new English model—but this time very important inquiries for navigation were made. Arostegui proposed a route using only latitude and some geographical references—islands and straits—and recommended reaching 58° south and from this point overcoming Cape Horn.[4]Some years before, the navy had made an expedition to examine the Patagonian coast and locate useful ports to land on long navigations (Martínez Martín 1991).

During the 1750s, there was progress, but the real advance began after the Seven Years' War (1756–1763). This conflict clearly showed that competition and rivalry had spread to all corners of the globe; Europe was a key scenario but also North and South America, India, Africa, Asia, and the Pacific. Spain entered this war in 1759 and, after the Peace of Paris, the Crown realized that another global context had been forged. The Spanish monarchy had to adapt to it and throughout the 1760s and 1770s, there were profound transformations. Commerce within the empire was liberalized through the decrees of 1765 and 1778. This meant that several Spanish

[3] AGS, SMA, leg. 404, exp. 234.

[4] AGS, SMA, leg. 405, exp. 270bis.

ports could trade without limits with America, which exponentially increased exchanges. In 1764, the Maritime Post was created to improve the communication of the monarchy and the circulation of information. At first, a single route was created between Corunna and Havana—and from there to the entire empire— but in 1767 another course was created to Buenos Aires in order to speed up the links with Rio de la Plata, Peru, and Chile (Baudot Monroy 2015). At the same, administrative reforms were implemented within the empire, the navy was strengthened, and shipbuilding was transformed (Kuethe and Andrien 2014). This last aspect is especially important; the model proposed by Jorge Juan following the English system was replaced by another one from 1765. The new system of shipbuilding, which was based on the French model, prevailed until 1780 and was characterized by faster navigation.

After the Seven Years' War, a new era for the navy began. King Charles III set new goals in order to respond to the growing economic competition and military rivalry over wide regions of the globe. Naval expeditions had to reach two objectives: on one hand, improving navigation following scientific progress on longitude and other instruments; and on the other hand, opening new routes to regions that were unknown for the Spanish monarchy. There is little doubt that this period was key because the number of routes within and outside the empire grew exponentially.

The North Atlantic was still the most important area for the Crown as most of the routes ran in this sea. Nevertheless, important shortcomings remained that hindered navigation. Between 1773 and 1774 Juan de Lángara—an important naval officer—made an innovative expedition to calculate the longitude and correct some data of this region. At that time the calculation of the longitude was still precarious –the English and French monarchies were also experimenting with nautical clocks—so it was necessary to offer much more reliable information about the locations of ships. This commission was a starting point for creating more and better data on this route and facilitated navigation between Spain and the Caribbean, New Spain, and New Grenade. In 1782, the Secretary of State for the Navy had several reports in which multiple routes through the North Atlantic were developed; they offered multiple options, depending on the season, the winds, the size of the convoy…[5] For instance, in 1781 the frigate *Santa Lucía* transported letters and weapons to Havana, but used a "confidential" course through Mariguana and Canal Viejo: "From Cádiz the frigate will sail southwest to latitude 32° 27′, approximately 28 leagues from Cape Cantin. From there it will head south 1/4 southwest and cross between the Canary Islands and the coast of Africa to avoid the corsairs. From here it will sail until discovering the island of Mariguana, which is at 22° 45′ north latitude, or the island of Caicos, which is 12 leagues southeast and at latitude 21° 50′".[6]

Another area that became very important during the second half of the eighteenth century was the South Atlantic. Numerous English, French, and North American

[5] AGS, SMA, leg. 425 exp. 1–27.

[6] AGS, SMA, leg. 421, exp. 30.

ships sailed through this sea due to fishing and smuggling. Military tension grew and the route between Spain and Río de la Plata changed into more frequent for the navy. The Secretary of State for the Navy proposed several commissions that sought to improve navigation, increase maritime knowledge on these coasts and make geo-strategic discoveries. This explains why the naval base of Montevideo was created in 1769, a landing point for the navy's ships and an enclave for military expeditions in this area.

In 1766, captain Francisco Medina commanded a division of two ships-of-line and four minor boats from Ferrol to Montevideo. On this trip, Medina made many annotations on the winds and on the sea currents, but the description of the route was very rudimentary[7]; there were very few references on latitude and no information on longitude. Some years later, in 1769, Pedro Trujillo made another navigation to the Río de la Plata. He had more information and navigation was easier, although it was still a route to analyze.[8] The improvements in navigation, although slow, were hand in hand with the geographical discoveries made by the navy. The Patagonia region was surveyed by various officials, such as Perler (1767), Piedra (1778–1779), and Viedma (1780–1784). At the same time, the Falkland Islands became a highly contested area and the Spanish monarchy decided to impose its sovereignty through various military expeditions. The most important commission was carried out by Francisco Gil (1768–1769); he made several advances for navigation among the Falkland, Montevideo, and Spain, and some years later he became the first governor of these islands.

Beyond the Atlantic, the challenges of the new global context led the Pacific to acquire much more importance. The growing connections between America, Asia, Africa, and Europe caused this ocean, which had been the "Spanish lake" for a long time, to become a highly contested space. The South Pacific, or the South Seas, was key to the Spanish empire since the viceroyalty of Peru and the captaincy general of Chile looked towards it. While direct trade between Peru and Spain grew, enemies frequented these seas to fish and smuggle. Viceroy Manuel Amat (1761–1776) realized this problem and promoted a policy of surveillance and control (Mellén Blanco 2011). The navy had an essential role because it had not only to defend these coasts but also to know these seas to navigate and improve communications.

Despite research on the Cape Horn route, even in 1780, it was still difficult navigation; there were many problems and it was necessary to improve knowledge about latitudes, winds, and ocean currents. This was clear when in 1780 the frigate *Santa Paula* sailed to Lima via Cape Horn and managed to try a rather innovative route. This expedition is interesting because the officer introduced some notes on longitude, although the calculation was rudimentary and more needed to be known about the coasts and winds of South America.[9] In any case, during the 1770s, there were relevant advances; the navy had made several expeditions to the South Seas and did

[7] AGS, SMA, leg. 409, exp. 323.

[8] AGS, SMA, leg. 411, exp. 710.

[9] AGS, SMA, leg. 422, exp. 501–504.

research in the navigation to Tahiti, Easter Island, Chile, and Lima. The most important commissions were executed by Haedo (1770–1771), Boneachea (1772–1773, 1774–1775), and Lángara (1775–1776).[10]

One of the novelties of this period was that the navy had to investigate seas and regions that the Spanish had not frequented before. An example was the North Pacific and the west coasts of North America, an area that was discovered by Russians, English, and Spanish in the 1760s. The increasing pressure in this region caused the navy to find a naval base in San Blas of California (Pinzón Ríos 2017). From this point, multiple expeditions were made, and Monterrey, San Diego, and San Francisco were founded. In the 1770s, three expeditions were projected (Bernabeu Albert 1992; Fuster Ruiz 1998; Ruiz Rodríguez 2013)and the navy had to acquire practical knowledge about these seas and create maritime routes as well as geographical discoveries. In 1774, Pérez Hernández sailed up to 60° north and in 1775 the officers Heceta and Bodega reached 65° north. Some years later, in 1779, Arteaga and Bodega repeated the expedition.[11] These voyages were also important because introduced improvements in longitude and were able to calculate very exact positions.

Another great milestone of this period was the direct navigation to Asia. During the sixteenth, seventeenth, and first half of the eighteenth centuries, communication between Spain and the Philippines was across New Spain, through the so-called galleon of Manila-Acapulco. This trans-Pacific route became obsolete in a time of growing connections, so the Crown tried to make a direct route between Cádiz and Manila via the Cape of Good Hope.[12] This way had been banned to Spain (Crespo Solana 2020), but in 1765 the navy opened a new course and over the next 20 years 13 voyages were made (Alfonso Mola and Martínez Shaw 2014; Jurado Cerón 2016). The first inquiries sought to create a basic knowledge about this route, essentially about stations, winds, ocean currents, latitudes "The most favourable season for this navigation is winter, from November and December to March. In November there are hurricanes in the straits, although the weather worsens in January, February and March. In the other months, the weather is better, and the winds come from the second quadrant. The landfall in Manila in June, July and August, which is the winter season there, has some storms".[13]

Especially important were Lángara's navigations. He commanded the frigate *Venus*—a boat built in 1755 according to the English model proposed by Jorge Juan—between 1771 and 1773 and made various calculations and investigated the winds and currents of the Indian Ocean and the seas of China. Lángara applied the most innovative techniques of that moment to measure longitude through the observation of lunar distances. The classic route across the Pacific, i.e., between Manila

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[10] AMN, 234, Ms. 413.

[11] AMN, 296, Ms. 575bis; Archivo General de la Marina Álvaro de Bazán (AGMAB), Expediciones a Indias (EI), leg. 1, exp. 4.

[12] AGS, SMA, leg. 412, exp. 5–6.

[13] AMN, 380, Ms. 917.

and Acapulco, was also revised (Baudot Monroy 2019). The works of Thompson (1773) and Rua (1780) made a new course for the galleons of Manila possible. They proposed going through northern Luzon instead of the San Bernardino Strait. In this way, there were better connections between Asia and the north coast of America, especially with Monterrey and San Blas.[14]

During this period there was another important expedition that reveals the importance of the global context. In 1777 Portugal ceded several islands in the Gulf of Guinea to Spain, and the navy made an expedition in 1778. The main objective of the mission was to take these territories, but also for other purposes (Crespi 2010; Ortega del Cerro 2020). The naval officer Varela Ulloa investigated the maritime routes of the Gulf of Guinea, acquired news about the coasts of Africa, and made several reports on the slave trade and the economy of these territories.[15] This officer concluded that navigation to these islands from Asia was not easy due to the winds and ocean currents, but communication between South America and Asia could be easier. However, Spain did not formally annex these islands, and navigation through this region was scarce during the eighteenth century (Santana Pérez 2018).

3 Increasing Information and Improving Paths in Global Context (1783–1797)

During the 1760s and 1770s, the traditional system of routes was dismantled, and the roots of a new network of courses were developed. The Spanish monarchy had managed to improve its ties with the North Atlantic, connect various points of the empire directly—Buenos Aires, Chile, Lima, California—, advance in the Pacific, and enter Asia and Africa. In other words, Spain was able to take part in the main global circuits and, in fact, its role was essential for many economic, political, and cultural exchanges around the world. After the American Revolutionary War (1776–1783), and during the 1780s and 1790s, a new stage was forged. Starting from this new map of connections, there was a qualitative improvement of the routes and the hydrographic knowledge progressed due to scientific advances.

This must be contextualized within the Ministry of Antonio Valdés, Secretary of State for the Navy between 1783 and 1795 (Guimerá Ravina 2012). He understood that multidisciplinary expeditions—those that had a military, scientific, economic, and political nature—were a fundamental pillar for the navy and undertook an ambitious program of research. The objective was to create, manage and publish relevant information for navigation. Beyond the Valdés policy, four fundamental factors must be noted to understand this period, such as the global context, the empowerment of the navy, scientific advances, and shipbuilding.

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[14] AGS, SMA, leg. 419, exp. 41.

[15] AGS, SMA, leg. 422, exp. 82; and AGS, SMA, leg. 425. AMN, 251, Ms. 469.

By 1780, global connections entered a decisive time; the pattern developed during the Early Modern Age was changing and a different one was slowly emerging (Bayly 2010). The quantity and quality of exchanges are good indicators of this problem: trade in tea, coffee, sugar or tobacco—considered global products due to production, circulation, and demand—grew exponentially (Carmagnani 2012), the number of slaves and tons of silver reached all-time highs, and financial transactions and other payment instruments expanded and generalized (De Zwart and Zanden 2018). These movements led to industrial production increasing, many sectors were transformed, and information circulated around the world faster.

The 1780s and 1790s were the golden age for the Spanish Armada (Guimerá Ravina and Chaline 2018, Marchena Fernández and Cuño Bonito 2018). The reforms promoted since the beginning of the century had matured and the increase of resources, budget, techniques, and personnel made that the *Real Armada* became the second most powerful navy in the world, although far from the British Royal Navy. 230 warships and 1600 officers were deployed around the globe; Cádiz, Ferrol, Cartagena, Havana, Veracruz, Cartagena de Indias, Montevideo, Concepción de Chile, Callao, San Blas de California and Manila were the main naval bases. The navy had to not only protect an immense empire but also to control a more interconnected world.

Throughout these two decades, there were also decisive technical changes. In 1782 Romero Landa—Chief of the Corps of Engineers of the Navy—proposed a new model of naval construction for the Spanish shipyards. Based on the French and English models, he proposed a series of modifications to make the ships faster, increase tonnage, improve sails and strengthen the hull (Juan-García Aguado 1995). These technical advances allowed the majority of the new vessels to be three-bridge. During these decades, there was also essential scientific progress for navigation (Sellés 2000); the calculation of the longitude improved and achieved great precision through the stopwatches as well as the measurement of the lunar distance. This was a key boost for the routes because sailors could calculate the exact position of the ship (Pimentel 2016). In 1787 Mendoza Ríos published *Tratado de Navegación*, a modern and updated guide for Spanish officers, in which all technical advances were included.

These factors allowed the Secretary of State for the Navy to carry out several important projects, such as research on the Spanish coasts. In 1783 Antonio Valdés proposed to make navigation charts of the coast of the Iberian Peninsula, a matter that might seem obvious but was still undone. Vicente Tofiño was the officer in charge of this commission and, throughout the 1780s, he and his team made reports, sketches, measurements, and calculations. In 1787 *Sailing off the coast of Spain in the Mediterranean* was published, in 1788 *Collection of nautical charts* and in 1789 *Sailing off the coast of Spain in the Atlantic Ocean*. All these works ended up collected in a single work, *Maritime Atlas of Spain*. This book is considered one of the most important culminating works of eighteenth-century Spanish navigation. Tofiño described and drew the Spanish coasts with unique precision by using all the technical advances of that time (Ródenas Valero 2015).

The efforts caused interest in the study of the Mediterranean to grow. Although it was a sea known for centuries, the scientific advances made the Spanish navy had to renew and update its knowledge. The eastern Mediterranean was especially suggestive due to its geographical, economic, and political characteristics. In 1783 Spain and the Ottoman Empire signed a friendship pact, and to formalize the treaty, a division of the navy was sent to Constantinople. During the expedition, Gabriel Aristizábal drew plans and formed courses for those coasts so little frequented (González Castrillo 2005).

There were more expeditions to the Ottoman Empire, Syria, and the eastern Mediterranean. In 1788 López de Carrizosa was the commander of a small squad whose official and the public mission was to transport two ambassadors to Constantinople. However, during the navigation, the officers did a lot of research and proposed several sea routes. They made reports on a multitude of islands, capes, sea currents and winds, in such a way that they created several round-trip courses in winter and summer.[16] Some years later, in 1796, Gabriel Císcar went to Tripoli and during this commission, he made new calculations about the Mediterranean. He was one of the top specialists on the measurement of the Earth's longitude and was able to correct some points that were wrong.

Beyond the European seas, there is little doubt that the North Atlantic was a preferred maritime area for the Spanish monarchy. Although communication with the empire had spread and diversified, the route between Spain and the Caribbean, New Spain, and New Grenade remained a fundamental axis. This area was very frequented by the rest of the European monarchies—trade with the Caribbean was one of the most lucrative activities of this time—and was, in fact, one of the most important global nodes. Having modern and up-to-date maritime knowledge was necessary, and the 1780s and 1790s were a productive period for Spanish research in this region. The expeditions that the navy carried out had two objectives, which were different and at the same time complementary. Some naval missions focused on ocean courses, that is, on maritime routes, through inquiries about latitudes, longitudes, winds, and currents. Other expeditions studied the coasts of North America, an obligatory matter to make correct navigation.

In 1787, the Secretary of State for the Navy proposed a project to raise modern and useful nautical charts of Septentrional America, as at that time the navy and merchant fleets only had a few old drafts made by pilots. This project was entrusted to Vicente Tofiño, but finally, it was not carried out. Some years later, and thanks to the impulse of Malaspinas and Mazarredo, this commission resumed and was organized in two divisions: on the one hand, the fleet commanded by Cosme Churruca to Trinidad, Barlovento, and the Antilles[17]; on the other hand, a squad to Tierra Firme under the orders of Salvador Fidalgo. The first expedition was short-lived (1792–1795) since the war against the French caused Churruca to return to Cádiz,

[16] AMN, 484, Ms.1403. AMN, 336, Ms. 722.

[17] The first task of Churruca was to translate eight English nautical charts, which were the basis for his later work. AMN, 235, Ms. 418.

but the second division carried out this purpose for 17 years (1792–1809) (González-Ripoll 1990; Martín-Meras 2008).

This project was in parallel to other expeditions that gave great results. In 1781, José María Chacón made accurate hydrographic charts of Campeche, in 1783 the Ministry of the Indies undertook a mission to the north of the Gulf of Mexico—from Florida to Tampico—commanded by José Hevia, and in 1792 Rigada carried out a commission of recognition to the Bahamas (González-Ripoll 2013). There were other expeditions that were especially important. Ventura Barcaiztegui was commissioned to make nautical charts of the island of Cuba. During 1790–1793 he made multiple reports, calculations, and measurements, in such a way that he managed to make an exhaustive portrait of the island (González-Ripoll 1991).

These efforts had immediate practical effects. The ships of the navy not only had to control the Caribbean Sea but also to defend possessions, convoy merchant fleets, and transport information, troops, weapons, and flows. The number of this type of expedition grew during the 1780s and 1790s, so it was possible to review the routes and make improvements. For instance, in 1783, the corvette *San Gil* and the frigate *Santa Agueda* convoyed several merchant vessels from Havana to Cádiz. Navigation was easy; the voyage began on 14th May and ended on 12th July, there were no setbacks, and the officers were able to keep a meticulous logbook. By using tables with daily information, they recorded heading, quadrant, distance, latitude, longitude, and winds.[18] This system was generalized within the navy and during the following years, the Secretary of State for the Navy obtained exhaustive navigation charts.

In 1792, the ship-of-line *San Pedro Alcántara*—built-in Ferrol according to the Gautier's or French system—sailed from Cádiz and arrived in Puerto Rico. Navigation was simple and straightforward, and its commander commented on the good quality of this ship to withstand very high speeds. This officer sent a table in which he summarized the navigation with daily information on latitude, longitude, distance, winds, and heading.[19] These data allowed that during the war against France (1793–1795) the ships of the navy that transported silver had alternative courses, and thus avert the enemy. For instance, in 1794 ships that load Mexican silver had to: "Outside the port of Havana, they will make manoeuvres to get to the meridian of Matanzas, and from there head northeast 1/4 north to recognise Cabeza de Mártires, at the beginning of the Channel of Bahamas. From here and marked the northern tip of Cayo Long to the west, they will sail north 1/4 northeast to reach latitude 28° 10′. In this parallel they will navigate up to 80 leagues east of the Bermuda meridian and then east northeast they will reach 35°. When considered to be at the same distance east of the meridian of Santa María, they will go to recognise the Cape of San Vicente and will coast for the south 5 leagues away. They will sail southeast to descend to the latitude of Cádiz".[20]

[18] AGMAB, EI, leg. 1, exp. 56.

[19] AGMAB, EI, leg. 13, exp. 71.

[20] AGMAB, EI, leg. 16, exp. 36.

The 1780s and 1790s were also an essential period for maritime knowledge and routes to the South Atlantic, Cape Horn, and the South Pacific (Maeso Buenasmañanas and Martínez Shaw 2007; Sagredo Baeza 2013). Antonio Valdés had a special interest in making progress in this area due to its economic importance—growth of Rio de la Plata, increased trade with Peru and Chile, and Asian connections. The Spanish monarchy had to reaffirm its position in these seas because the presence of English and North American ships—theoretically for fishing, although they were merchant ships—grew and the tension increased. The Spanish Crown created the Royal Maritime Company in 1789 with the aim of exercising whale fishing and colonizing various ports in Patagonia (Martínez Shaw 2008). In any case, these two decades was a very intense time for the navy because it had to make exhaustive reports on the coasts of South American as well as create modern knowledge about maritime routes.

During these years there were several expeditions to transport troops, information, and woods and to defend these coasts. In 1783 the frigate *Santa Amalia* went from Cádiz to Montevideo, in 1785 the ship-of-line *Santiago* from Lima to Cádiz, in 1786 the vessel *Nuestra Señora de la O* from Río de la Plata and in 1790 the frigate *Liebre* from Peru.All these navigations were important to improve the knowledge of the South Seas, but especially the last mission. The logbook of the frigate *Liebre* was sent years later to the Hydrographic Direction.[21] Routes through the South Atlantic, Cape Horn, and the South Pacific were difficult; the winds were usually contrary, and the calculations of latitude and longitude were still not easy. In any case, the expeditions continued. In 1790 the ships *Asia* and *Castilla* went to Peru as well as the frigate *Gertrudis*. In 1792 the frigate *Nuestra Señora de Loreto*—built in 1781 under the French system—sailed from Cádiz to Lima and made a stopover in Montevideo. From there an urgent notice was sent to Madrid: "This class of frigate is not suitable for the commission and destiny of carrying mercury to Peru, whose navigation requires less shallow, shorter and certified vessels, since it almost always collides with strong and high seas, so the vessel suffers a lot. On the other hand, this frigate lacks the necessary spare parts required. Its diligence is scarce, because if the winds are impetuous, they drive enough to any ships of these proportions to make these trips short and comfortably, as several commercial ships and war frigates of the old construction have done".[22]

This comment was correct. A few days later this frigate was shipwrecked. Anyway, the progress of the knowledge of these seas was outstanding, which allowed that during the war against France (1793–1795) the warships had alternative routes to navigate safely. "Once you have passed the Punta de San José, you will sail east-southeast, passing through Isla de las Flores a league away on port side. From here you will navigate east 1/4 southeast until you pass Isla de Lobos and then head east the distance of 150 or 160 leagues. At this point you will find the general south-southeast winds to the southeast, taking a northeast direction 1/4 east. To the

[21] AGMAB, EI, leg. 11, exp. 118.

[22] AGMAB, EI, leg. 13, exp. 76.

north you can see the island Trinidad and the islet of Martín. From here you will sail north to cut the equinoctial at 15° 30′ of the Cádiz meridian. From here you will sail north northeast, and you will reach 40 or 50 leagues from the Cape Verde Islands...”.[23]

The navy undertook other political and scientific expeditions that were essential. The officer Varela Ulloa was in charge of delimiting the borders in Río Grande between 1784 and 1796, an objective that Gutierrez de la Concha continued between 1795 and 1802. In 1789 there was a project to probe Río de la Plata, although this mission was not finally concluded. The southern Pacific coast—Chile—was recognized through several expeditions in 1789 Clairac), 1790–1791 (Elizalde) and 1792–1795 (Moraleda)[24] (Maeso Buenasmañanas 2009; Sagredo Baeza 2009). However, the most important commission was the reconnaissance and hydrographic study of the Strait of Magellan. Antonio Córdoba was the commander of a division that made numerous reports on this area between 1785 and 1788.[25] In this way, the Spanish monarchy managed to have an exhaustive and reliable knowledge of a fundamental area for many maritime routes (Riera i Fortiana 1989; Vázquez de Acuña 2004; Vanwieren 2007). In fact, the results of this expedition were published in 1788 and 1793.

These scientific and geographical expeditions took place not only in the American Southern Cone, but also on the North American Pacific coast. The growing military rivalry among the English, the Russians, and the Spanish caused the navy to undertake various missions during the 1770s. This effort continued during the 1780s and 1790s (Fuster Ruiz 1998; Avalle-Arce 2000). Nine expeditions were carried out in this area with the objective of analyzing the coast, discovering better maritime routes, and founding some settlements. Martín and Haro (1788), Martínez (1789), Fidalgo (1790), Quimper (1790), Eliza (1791), Malaspina (1791), Galiano and Valdés (1792), Caamaño (1792) and Zapas (1793) were the officers in charge.[26] Because of these expeditions, the Spanish presence was strengthened, which caused the famous Nootka conflict between Spain and the Great Britain.

Finally, it is not possible to finish this section without mentioning the expedition of Malaspina (1789–1794). This mission was possibly the most important of the entire century due to its scientific, hydrographic, political, and economic nature (Pimentel 1998; Soler 1999; Galera Gómez 2010). Following the pattern of James Cook or Jean-François de La Pérouse, in 1789 Alejandro Malaspina proposed to do a mission through the South Atlantic, the entire Pacific coast, and Asia. The results were spectacular; Malaspina managed to generate an enormous amount of knowledge of natural history, cartography, ethnography, astronomy, hydrography, and medicine. It is necessary to highlight that thanks to this mission there was a great advance in Spanish hydrography. Malaspina used innovative techniques, corrected many data, and proposed new sea routes. However, the main results were not

[23] AGMAB, EI, leg. 19, exp. 96.

[24] AMN, 307, Ms. 613.

[25] AGMAB, EI, leg. 9, exp. 112.

[26] AMN, 197, Ms. 332. AMN, 296, Ms. 575bis.

published because Malaspina was imprisoned once he arrived in Spain; he was accused of a political conspiracy against the Prime Minister.

4 Forging a Corpus of Global, Maritime and Hydrographic Knowledge (1797–1815)

The crisis of the Spanish navy began in the final years of the eighteenth century and worsened at the beginning of the nineteenth century (Kuethe 2014). But while the economic and military decline of the institution was increasingly evident, the creation of hydrographic knowledge and the development of maritime routes reached its peak. The scientific and nautical efforts made since the 1750s culminated in these years; the navy had enough sources and documents to undertake the systematization of this knowledge. In 1797 the Hydrographic Direction of the Navy was created, a modern center that used new techniques and scientific advances for the study of navigation and hydrography. In this institution, the main results of the expeditions made up to that moment were archived, and there was an order for all commanders to send the logbooks of each mission from then on.[27] Spain had to make visible in Europe and the entire world the progress achieved by the navy, so the objective of the Hydrographic Direction was to analyze these documents and publish the main conclusions (González González et al. 2003).

In 1809, *Astronomical Observations Made by Spanish Navigators* was published, a work that symbolized the culmination of the efforts of the Hydrographic Deposit and showed the advances of the Spanish navy.[28] According to Luis María Salazar, this institution had already published numerous works, especially 31 nautical charts, which covered practically all the seas on the planet. The most important ones were: Spherical chart of the globe with the layout of the most famous navigations; General chart of the Atlantic Ocean, from 52° latitude to the Equator; General chart of the Atlantic Ocean from the Equator to 60° latitude, and from Cape Horn to the Mozambique Channel; Chart of the coasts of Spain, France, and Italy; Charter of the Mediterranean and the Greek archipelago, Constantinople and the Black Sea; General Charter of the Philippines (Salazar 1810).

Beyond the labor of the Hydrographic Direction, between 1797 and 1815 the navy continued to make progress on maritime routes and scientific advances for navigation. It is important to note that this work was done in the context of war. Spain had to face a war against France (1793–1795), two conflicts against the

[27] AGMAB, EI, leg. 29, exp. 85. AGMAB, EI, leg. 28, exp. 54.

[28] This publication had four parts: the first *memorial* deals with observations made on the coasts of Spain and Africa, and on those of the Mediterranean Sea, the Canary Islands and the Azores; the second part on the coasts of the continent of America and its islands from Montevideo through Cape Horn to 60° north latitude; the third one, the observations made in the Mariana Islands and the Philippines; and finally, the fourth *memorial* about practical astronomical observations in Puerto Rico, La Guayra, Cartagena de Indias, Havana and Veracruz.

English (1796–1802, 1804–1809), the War of Independence (1808–1814), and the emancipations of Latin America (1809–1820). Furthermore, from 1793 to 1815 Europe and the world were in conflict. The Coalition Wars not only changed the European map, but also the international balance in America, Africa, and Asia. Precisely this global dimension of the conflicts caused the navy to play a key role since beyond defending the empire, it had to continue to improve maritime routes and develop more hydrographic knowledge.

Research on the Spanish coast and the Mediterranean continued during this stage. After the important publications of Tofiño, the navy tried to correct some data. It was necessary to make new calculations and measurements, so Dionisio Alcalá-Galiano carried out a new commission with this aim. This officer had already participated in several scientific expeditions and had become one of the most reputable individuals in the officer corps. Alcalá traveled to Naples in 1802, and from there he went to the eastern Mediterranean to make new nautical charts (Sampedro Sánchez 2014). Through astronomical measurements, he located several islands and points in this sea as well as the latitude and longitude of the maritime routes.[29] Other officers, such as González, Enrile, or Cataló, completed this mission through other trips during the first years of the nineteenth century.

The North Atlantic and Septentrional America continued to be a privileged area for the Spanish monarchy. Fidalgo's mission to Tierra Firme continued until 1809 and the Churruca's expedition, which was canceled in 1795 by the war, was resumed with Ceballos (1802–1806). The results of both commissions were essential to create a maritime atlas of this region. In 1798 the Secretary of State for the Navy received a report entitled "Particular news for navigating and manoeuvring with practical and safe knowledge in the Mexican Gulf and other ports of North America"—a document with very accurate information—and one year later, in 1799, *Spherical Chart of the Gulf of Mexico and the Adjacent Islands* was published. During this stage, the navy achieved abundant, modern, and reliable knowledge through the contribution of multiple pilots, officers, and geographers, such as the memorial sent by the pilot Miguel Estayola to the Hydrographic Direction. This document, composed of six hundred pages, demonstrated advanced information of the North Atlantic and the coasts of Mexico, the Antilles, Central America, and New Granada.[30]

All these works made it possible to offer an exhaustive portrait of the Caribbean, Antilles, and coasts of New Spain and New Grenade. In 1810, the Hydrographic Direction promoted the book *Route to the Antilles Islands, the Coast of Tierra Firme, and the Mexican Gulf—Derrotero de las islasAntillas, de las costas de Tierra Firme y de las del senomexicano*—, maybe one of the most important achievements of the institution. In this work the main winds and currents of this area were explained, a detailed description of all the coasts and numerous advice and

[29] AMN, 201, Ms. 345.

[30] AMN, 156, Ms. 230.

warnings for the navigation was offered. This book had so relevance that was reprinted in 1820, 1826, 1837, and 1849, and even was published in Paris three times.

This knowledge could be applied and indeed made easier the numerous military expeditions that were sent to the North Atlantic during this period. The warlike context forced them to look for new courses, but the warships could use the new hydrographic information. For example, in 1800 the ship-of-line *San Pedro Alcántara* had the order to return to Cádiz from Havana with a large load of silver. His commander thought that he should set sail in winter because it was a safer season, although unfavorable for navigation.[31]This situation also caused the navy to look for direct sea routes to the United States of America, whose ports were safer to make landfall and not be attacked by the British.[32]

The situation in the South Atlantic and South Pacific was similar. Although the presence of enemy ships increased—Buenos Aires was invaded twice, in 1806 and 1807—, the expeditions of the navy to the Rio de la Plata and Lima were constant. By 1800 the coast of South America was already well known[33]; many reports had reached the Secretary of the Navy and alternative routes could be proposed. For instance, in 1797, two frigates and a corvette formed a convoy with 30 merchant ships. The commander was able to create an innovative course thanks to technical advances in navigation: "The route must be guided by longitude observations to measure the equator at 20 or 22° west of Cádiz, and from this point navigate with breezes to the southern parallels of the island of Santa María, at a distance of 20 or 25 leagues. Navigation will be before reaching the meridian of this island, because the enemies have their cruises in this area…".[34]

Another achievement of the navy was the increasing control over Cape Horn, an essential step for the Spanish expeditions to Peru, California, and Asia. Because of many years of research and testing, the Secretary of State for the Navy managed to form an efficient route. After reaching Cape San Agustín, in Brazil, and sailing to Rio de la Plata, the vessel had to catch the Patagonia probe, at latitude 47° south; carefully controlling the depth, they would sail to the Isle of States. At this point, the ship passed Cape Horn until reaching 60°, but from there the course had to change and take the Chilean coast until reaching Chiloé.[35] The work of Malaspina was very important for this route, which was revised years later, through a mission commanded by Colmenares and Moraleda (1801).

Finally, this period was especially important for the routes and hydrographic knowledge of Asia (Elizalde 2020). Although there were advances since the 1760s, key discoveries were made during the early years of the nineteenth century. A squad commanded by Ignacio María Álava was sent to Manila between 1795 and 1803. This expedition made a great effort to improve information on Asia (Herrero Gil

[31] AGMAB, EI, leg. 27, exp. 108.

[32] AMN, 139, Ms. 176.

[33] AMN, 118, Ms. 129.

[34] AGMAB, EI, leg. 22, exp. 109.

[35] AMN, 485, Ms. 1404.

2012; Alfonso Mola and Martínez Shaw 2014), summoned the galleon of Manila-Acapulco several times, and was able to discover new islands in the Pacific, such as Midway in Hawaii.[36] Another important discovery was the so-called Strait of Gaspar, in Indonesia, which made it possible to open a new route between the Philippines and Spain through the Indian Ocean.[37] During these years, Commander Álava also designed a special route for the Royal Company of the Philippines; this officer planned a direct course between Lima and Manila, which became a success (Díaz-Trechuelo 1965; Alfonso Mola and Martínez Shaw 2018). This first project crossed the entire Pacific Ocean following the equator, but years later a new version was created, through Australia, New Zealand, and the South Pacific.[38]

At this stage, numerous reports were sent to the Secretary of State for the Navy, and all of them demonstrated the remarkable progress achieved. The "route from Cádiz to Manila in the Philippine Islands," written by Alonso de la Riva, was especially important. Navigation was divided into eight large sections, in each of which a detailed description of the winds and ocean currents was made. For example, the section "from 10° south to the equator, this is, the end of one monsoon and the beginning of another one" deals with the sailing of the Indian Ocean, whose winds were explained: "From 10° south the monsoons generally begin (this word means season). According to the famous pilot Lorenzo Subilan, the winds from April to October are constant from the southeast and from October to April from the northwest in the southern hemisphere. From April to October, when south-eastern winds reign in the said hemisphere, the weather is generally clear and serene, and in the first 3 or 4 months, that is, in April, May, June, and July they usually experience some revolutions from the northwest in the last two, the breezes from the southeast are usually cooler, but in clear weather. Near the equator, the winds are variable, less safe and constant."[39]

Navigation to and from Asia had improved. A good example was the voyage of the frigates *Aurora* and *Ferroleña*—both boats were built in Ferrol, in 1796 and 1797, according to the new Spanish model, devised by Romero Landa—which urgently traveled from Cádiz to Manila in just three months to announce the Peace of Amiens.[40] After these advances, the navy made several expeditions in collaboration with the Royal Company of the Philippines. In 1803, Vernacci traveled to Coromandel and Cataló went to Calcutta. These missions allowed us to understand the economic reality of India as well as improve the routes through the Indian Ocean.[41] There was even a project of the route in 1814 that ran from Cádiz, Manila, Canton, and Buenos Aires.[42]

[36] AMN, 101, Ms. 96.

[37] AGMAB, EI, leg. 21, exp. 34.

[38] AGMAB, EI, leg. 34, exp.58.

[39] AMN, 123, Ms. 138, doc. 1.

[40] AMN, Ms. 576.

[41] AMN, 187, Ms. 307.

[42] AMN, 395 Ms.1020.

5 Conclusions

The objective of this work was to analyze the development of hydrographic knowledge and the creation of new maritime routes by the Spanish navy during the second half of the eighteenth century. Historiography has largely focused on scientific expeditions and hydrographical advances, but less attention has been paid to the forging of a vast, extensive, and complex network of naval courses throughout the world. A simple comparison between the connections of the 1750s and the 1810s is revealing. By the mid-eighteenth century the Spanish empire linked through the system of galleons and fleets, i.e., between Cádiz and Caribbean—Veracruz, Portobello, Cartagena de Indias, and Havana—, and from this area to Peru across Panama and to the Philippines through Acapulco. In 1810 the navy had improved the courses to New Spain and New Grenade and had achieved safe and direct routes to Rio de la Plata, Chile, Peru, California, Manila, Guinea, India, China, several points of the Pacific and controlled the Cape Horn.

Ultimately, this chapter attempts to examine how the navy managed to insert the Spanish monarchy into the main global circuits. During the second half of the eighteenth century, there was a quantitative and qualitative advance in the communications of Spain, both inside and outside its empire. However, this phenomenon is explained by several factors, such as the changes in the global context, the strategy, and priorities of the monarchy, imperial policy, the role of the navy, scientific progress, the development of nautical science, or shipbuilding. This multidimensional approach has been applied to this study in order to understand the complexity of the problem. For this purpose, three phases of analysis have been proposed.

The first stage started after the Jenkin's Ear War (1739–1748). The Spanish monarchy understood that the communication and trade system—fleets and galleons—was obsolete and had to change. Increasing military pressure and economic competition forced a review of the old connections between Spain and the Caribbean; it was necessary to improve the classic routes—mainly the North Atlantic—and develop new courses with various points of the empire, such as Buenos Aires or Peru through Cape Horn. These efforts yielded minor results and deeper changes began in the 1760s.

The Seven Years' War (1756–1763) was a turning point; the global context was changing, and Spain had to respond to this challenge. The monarchy had to go further, create a new map of connections for the empire and open new routes with other parts of the world. The navy inquired and created courses to South America, Africa, and Asia, and naval officers sent numerous reports to the Secretary of State. At this stage, there were also scientific advances that were decisive for the new routes, especially the new techniques for calculating longitude and latitude. Lángara made a very innovative expedition to measure longitude in the North Atlantic and there were important discoveries in Patagonia, South Pacific, and California. In this period the monarchy also managed to create a direct route to Manila—via the Cape of Good Hope—and to Africa.

During the 1760s and 1770s, a new and extensive network of connections was created, but after 1783 there was a qualitative step forward. The techniques and calculation of longitude improved—both with stopwatches and lunar measurements—and allowed to develop nautical science. After a great effort, naval engineers upgraded shipbuilding and got faster vessels, with better maneuvering. The Spanish navy was empowered, and the Secretary of State embarked on a very ambitious program of expeditions. Tofiño's publications were a good example, as well as the inquiries about the eastern Mediterranean. The Ministry Antonio de Valdés proposed a project for a maritime atlas of the Atlantic of North America, and many hydrographic commissions were carried out. In addition, in the ordinary missions of the navy—to control coast and transport silver or troops—, the officers made improvements and progressively corrected data on the routes. Cape Horn was thoroughly analyzed, and a safer and more efficient route was created. The best example of this golden age of expeditions was the Malaspina's project, a commission around the world with hydrographic, physic, economic and political aims.

At the end of the eighteenth century, the crisis of the Spanish navy began; too many open wars and a smaller budget caused the institution to collapse. Nonetheless, it was an outstanding period for hydrography and maritime routes. In 1797, the Hydrographic Deposit was created, a center that kept and analyzed all the efforts made up to that moment. One of its objectives was the publication of the works of the navy and, at the same time, showed that the Spanish monarchy achieved modern knowledge and techniques. These advances had important applications, as warships were able to improve navigation and propose alternative courses in wartime. In addition, there were more inquiries in various parts of the world, especially in Asia, where the Spanish navy continued to investigate routes to India and South America for the Royal Company of Philippines. With these efforts, the navy was able to get to know and sail all the seas of the globe.

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Chapter 12
Technology of Iron Anchor-Frame Production in the Age of Exploration

Gregory Votruba

Abstract It is evident that iron anchor-frame sizes and construction undergo considerable changes in the second millennium CE into the Age of Exploration. Their construction changes from baton-assembled or laminated-beam to lone-bar then bundled-bars construction. Although numerous complex factors are involved, it is suggested that the most significant factor was the inclusion of waterpower, and its successive development, for iron production technology. These developments allowed for a dramatic increase in size and weight of anchor frames. This enhancement in nautical technology should be considered a significant factor resulting in the increasing sizes of vessels and unprecedented capacity of nautical activity resulting in and facilitating, globalization.

1 Introduction

Iron-frame wood stock-anchors are among the preindustrial period tools representing the highest level of a society's technical capabilities and economic well-being. The health and efficiency of maritime economies would largely have been based on the function and reliability of their anchors; not least to inhibit shipwreck during storm but for control and comfort of navigation and anchoring generally. It is, therefore, reasonable to suspect that limitations and advances in iron-working and anchor-frame construction could have played an intrinsic role in the nature of a society's nautical culture and the economy generally. For the European continent, the Age of Exploration offers a unique circumstance where an obvious and profound change in nautical culture occurs, the earliest period of repetitive long-distance oceanic navigation and its sustained expansion. Although there were of course certain economic and political drivers, it can be proposed that developments of anchor construction made it possible to now anchor comfortably along the shores of the open oceans, rather than merely the relative calm of Mediterranean and northern European basins.

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The most obvious functional characteristic of iron anchor frames is their size. The relevant treaty authors regularly distinguish stock anchors solely by their weight, with their distinct identification on board (sheet, bower, kedge, etc.) only being a matter of relative weight to others of the complement and size of the ship. Most authorities distinguish ships' anchors' sizes (regularly weight) as relative to a measure of a ship's size (most commonly burden; e.g., de Chaves 1537: 219, Bartolomeo Crescentio 1607: 77–78, and Fournier 1643: 43–44). Work is in progress for synthesizing the modest diachronic and spatial anchor design variations of this period as well as the relationship of ships' sizes to stock-anchor sizes and size variations among ships' complements. Different anchors in a complement would have had the same overall design with Mainwaring most clearly informing, "… for that which in one ship would be called but a kedger, or kedge anchor, in a lesser, would be a sheet anchor" (1644, p. 2). This chapter follows this paradigm *sensu stricto*, focusing solely on the overall anchor-frame dimension and technology of construction.

Early treaty authors all testify that the heavier the anchor, the larger the ship that it can serve. In other words, the heavier the anchor the greater its potential holding resistance. Anchor-frame size is a factor of the availability of iron as well as techniques and tools to enable the construction of a durable product. Provided sufficient iron is available, large anchors can be produced in any period, but technological limitations may result in a product that fractures readily and is therefore impractical. Therefore, in order to investigate anchor-size increase, it is necessary to consider both iron production methods in conjunction with construction techniques.

The scope of this chapter isolates size variation in iron anchor frames in the second millennium centuries preceding and during the Age of Exploration through ca. CE 1650. This can be attempted largely because of the recent commencement of scuba diving and the subsequent development, albeit gradual, of marine archaeological techniques, which has resulted in the publication (of varying quality and preservation) of dozens of relevant anchor frames from tens of datable sites. However, later data seem to be complicated by certain bias. The publication seems to be largely limited to sixteenth-century material and earlier. Perhaps there is a misconception that treaty writing, which first becomes detailed in the seventeenth century, renders seventeenth-century anchor publication redundant. Nevertheless, combining the evidence of published frames (see Catalog and Figs. 12.1, 12.2, and 12.3) with the evidence from the treaties provides an overview of this formative period for general hypothesis building (Table 12.1).

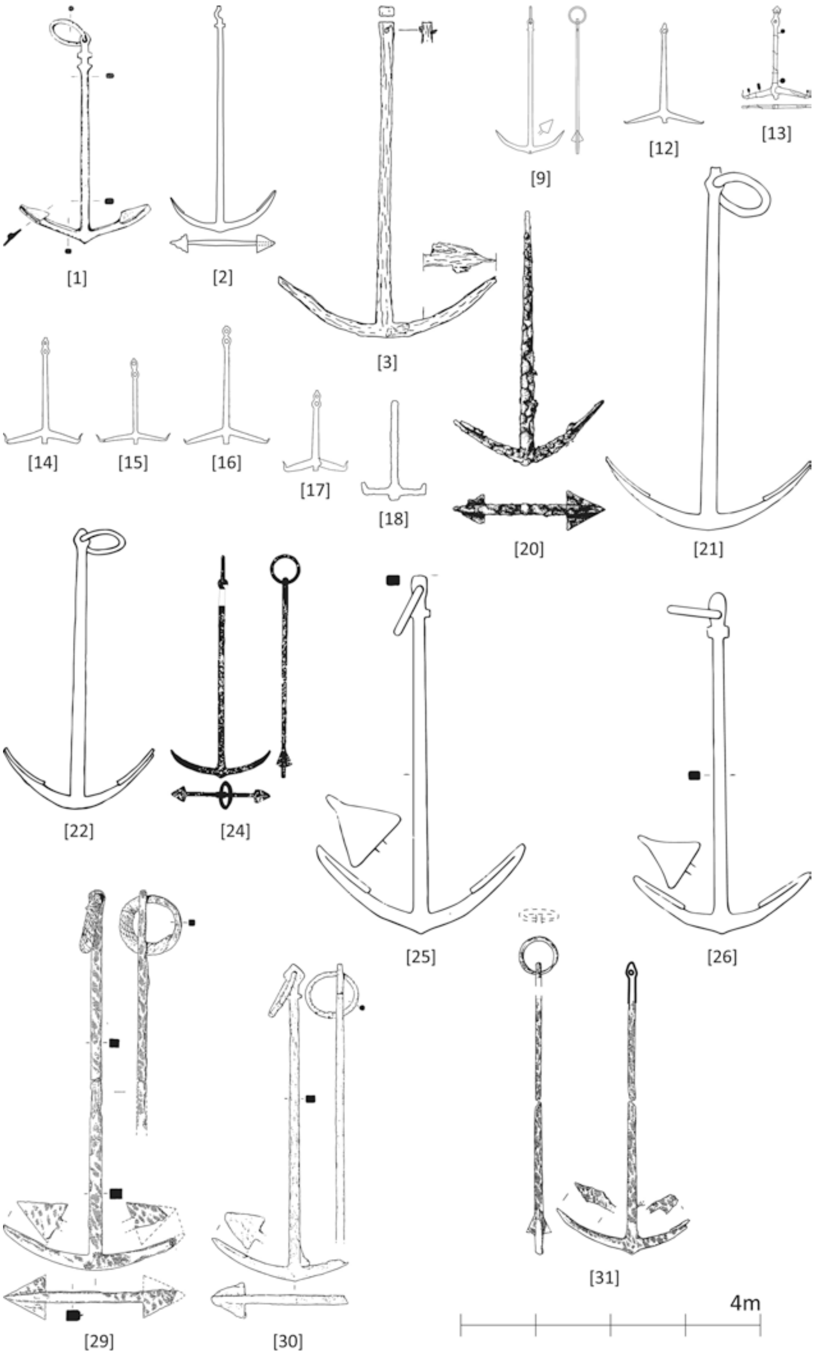


Fig. 12.1 Tracings of iron anchor-frame illustrations. See Catalog for original illustration citations [1–31]

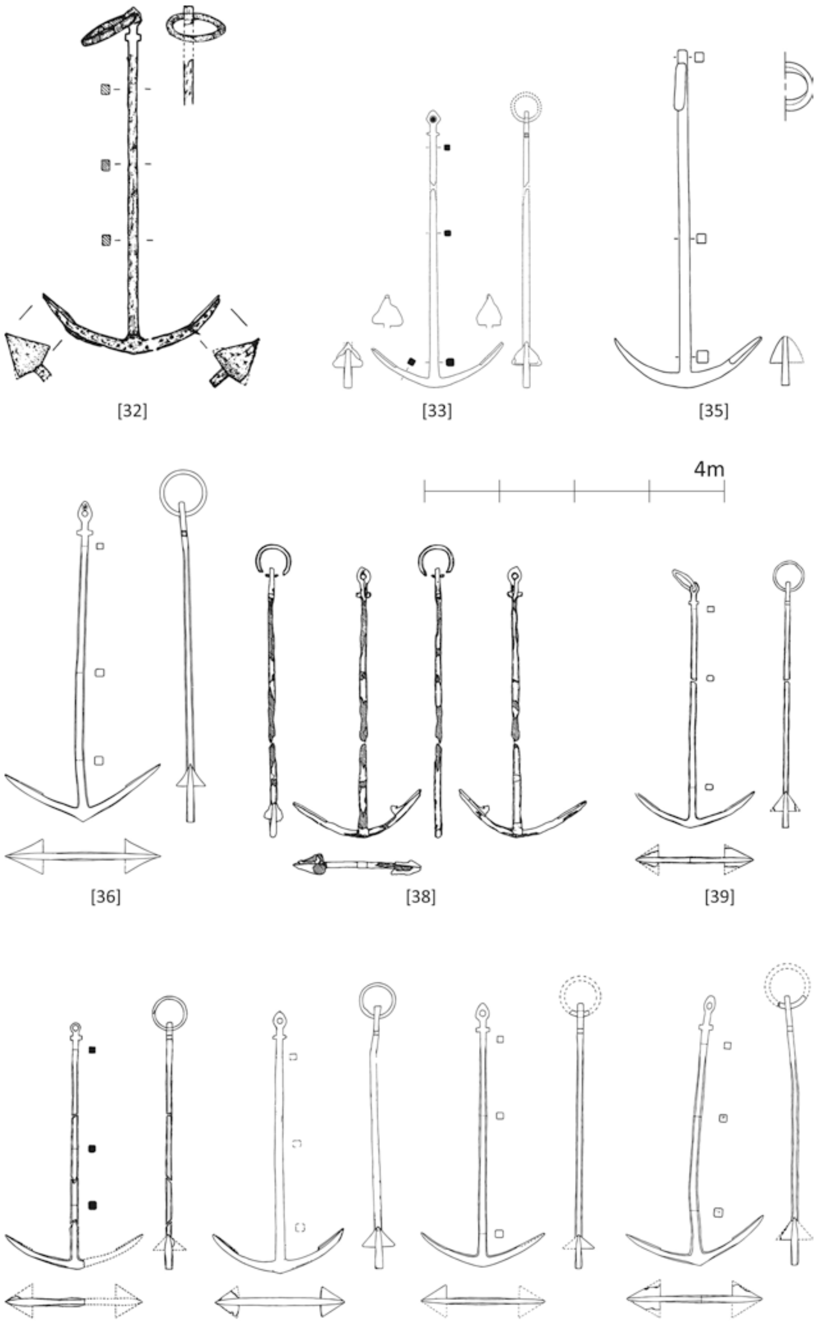


Fig. 12.2 Tracings of iron anchor-frame illustrations. See Catalog for original illustration citations [32–43]

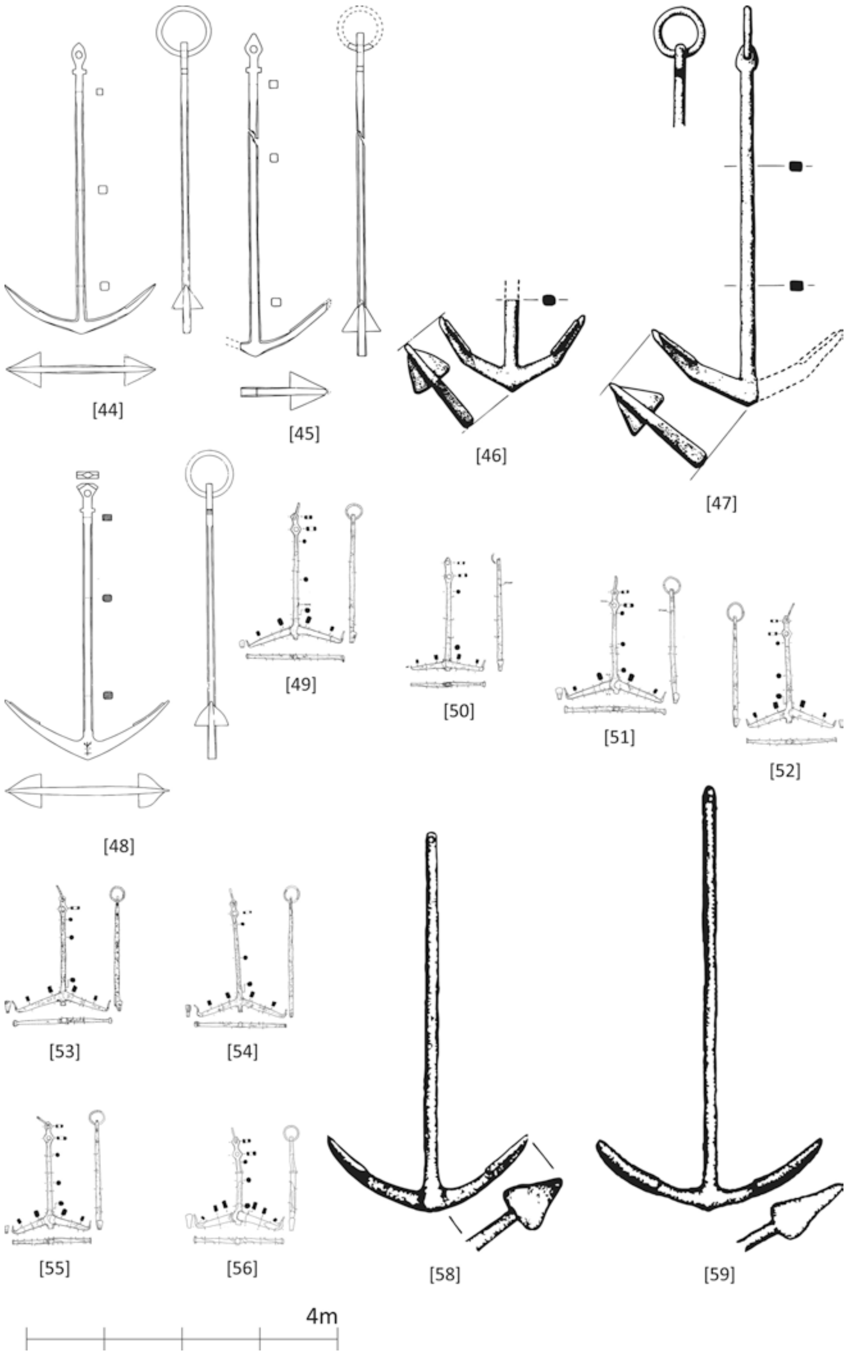


Fig. 12.3 Tracings of iron anchor-frame illustrations. See Catalog for original illustration citations [44–59]

Table 12.1 Catalog of anchor-frame findings cited in the text

Anchor Frame Reference ID	Site Name	Citations	Object Identifier	Traced Line Drawing Citation (Fig. 12.1)
[1]	Atlit Ordnance ship	Galili and Rosen (2014)	N/A	Galili and Rosen (2014, Fig. 5)
[2]	Bahia Mujeres	Keith (Keith 1988a, p. 122 and Fig. 7); Keith (1988b, pp. 56–7 and Fig. 20); Jobling (1993, pp. 56–58 and Fig. 9)	N/A	author reconstruction based on Keith (1988a, Fig. 7)
[3]	*Batavia*	Green (1977a, pp. 51, table 4); Green (1989, pp. 1, 5, 104, 213–5 and Figs.1, 3, 5, 25)	BAT 80311	Green (1989, p. 104 lower)
[4]			Green 1989: Fig. 5, no. 2	N/A
[5]			Green 1989: Fig. 5, no. 3	N/A
[6]			Green 1989: Fig. 5, no. 4	N/A
[7]			Green 1989: Fig. 5, no. 8.	N/A
[8]			Green 1989: Fig. 5, no. 9	N/A
[9]	Bremen Kogge	Lahn and Ellmers (1978, pp. 103, 106–7) Borsig (1981); Ellmers (1988, pp. 157–8)	N/A	Borsig (1981: Fig. 2)
[10]	Çamaltı Burnu 1	Günsenin (Günsenin 2001, 2003, 2005) and Kocabaş (2005 cat. Ç 02, 03, 04, 07, 10, 12, 20, 25 , 2008, 2009)	An Wr 2	N/A
[11]			An Wr 4	N/A
[12]			An 3	Kocabaş (2005: cat. Ç 03 drawing)
[13]			An 4	Kocabaş (2008: Fig. 5)
[14]			An 7	Kocabaş (2005: cat. Ç 07)
[15]			An 10	Kocabaş (2005: cat. Ç 10)
[16]			An 12	Kocabaş (2005: cat. Ç 12)
[17]			An 20	Kocabaş (2005: cat. Ç (20)
[18]			An 25	Kocabaş (2005: cat. Ç 25)
[19]			AN 26	N/A
[20]	Emanuel Point	Smith et al. (pp. 1, 4, 7, 28, 44, 64, 119, 165–8, 174); Burns (1998)	N/A	Burns (1998: Fig. 31)

(continued)

Table 12.1 (continued)

Anchor Frame Reference ID	Site Name	Citations	Object Identifier	Traced Line Drawing Citation (Fig. 12.1)
[21]	Gnalić	Petricioli (1970, p. 9); Martin (1979, p. 32)	Petricioli (1970: Fig. 10, left)	Petricioli (1970: Fig. 10 (left))
[22]			Petricioli (1970: Fig. 10, right)	Petricioli (1970: Fig. 10 (right))
[23]	Highborn Cay	Peterson (1972, Fig. 14, 1974 p.235 and Figs 1, 4, 5); Smith et al. (1985 p.61, 63, 68 and Fig. 4); Keith (1988b, pp. 59–60); Oertling (1989, pp. 235, 241)	N/A	N/A
[24]	Kalmar Harbour, Slottsjarden	Åkerlund (1951, pp. 119–20, 151, 155, Figs. 86 and pl. 1 and 27, d); Lahn and Ellmers (1978, p. 107)	N/A	Akerlund (1951: pl. 27d)
[25]	*La Trinidad Valencera*	Martin (1979, pp. 31 and Figs. 3, 6, 7, 16)	northern	Martin (1979: Fig. 16 (left))
[26]			southern	Martin (1979: Fig. 16 (right))
[27]	Malamocco	Molino et al. (1986)	N/A	N/A
[28]			N/A	N/A
[29]	*Mary Rose*	Rule (1982, pp. 134–5); Marsden (2003, p. 110 and Fig.11.20); McElvogue (2009, pp. 276–81 and Figs. 15.7, 15.9, 15.10)	cat. no. 81A0646	Marsden (2003: Fig. 11.20 (lower))
[30]			cat. no. 82A4078	McElvogue (2009: Fig. 15.7b)
[31]			cat. no. 82A4079	Marsden (2003: Fig. 11.20 (upper))
[32]			cat. no. 05A0104	McElvogue (2009: Fig. 15_7c)
[33]	Molasses Reef wreck	Keith et al. (1984, pp. 45–46, 61 and Fig. 3); Keith and Simmons (1985, pp. 420–3 and Figs. 4, 6, 7, 8); Keith (1986, p. 7); Keith (1987, pp. 235, 242–6 and Fig. 104); Keith (1988a, pp. 118–19 and Fig. 4); Oertling (1989, pp. 230, 235, 240)	N/A	Keith (1987: Fig. 104)

(continued)

Table 12.1 (continued)

Anchor Frame Reference ID	Site Name	Citations	Object Identifier	Traced Line Drawing Citation (Fig. 12.1)
[34]	Mortella II	Cazenave de la Roche (2009, pp. 6–7, 15, 24 28, 44–49 and Figs. 2, 10, 27–30); Cazenave de la Roche (2011, pp. 76–8)	N/A	N/A
[35]	Mortella III	Cazenave de la Roche (2009, pp. 6–7, 15, 24 and Figs. 4, 5, 11, 31–3, 43); Cazenave de la Roche (2011, p. 78)	N/A	Cazenave de la Roche (2009: Fig. 33)
[36]	Padre Island - 1554 salvage vessel (?)	Arnold and Weddle (1978, pp. 212, 224, 230 and Figs. 16, 17)	N/A	Barto Arnold and Weddle (1978: Fig. 16 (right))
[37]	Paphos Airport	Howitt- Marshall et al. (2016, pp. 175, 178–9 and Figs. 1, 2, 3, 6)	N/A	N/A
[38]	Red Bay, Newfoundland	Light (1990, 1992, pp. 249–53); Moore et al. (2007, pp. 76–8 and Fig. 17.4.17)	N/A	Moore et al. (2007: Fig. 17.4.17)
[39]	*San Esteban* (?) - Padre Island	Arnold and Weddle (1978, pp. 88, 224, 230, 224, 230, 296, 302–3 and Figs. 11, 13–16, 21, 70, 74, 75, 77 and tbl. J.1); Keith (1988b: Figs. 8, 9, 10, 11)	cat. no. 157	Arnold and Weddle (1978: Fig. 13 (left))
[40]			cat. no. 161	Arnold and Weddle (1978: Fig. 13 (center))
[41]			cat. no. 80-1	Arnold and Weddle (1978: Fig. 14 (left))
[42]			cat. no. 156-1	Arnold and Weddle (1978: Fig. 14 (center))
[43]			cat. no. 156-2	Arnold and Weddle (1978: Fig. 14 (right))
[44]			cat. no. 159	Arnold and Weddle (1978: Fig. 15 (right))
[45]			cat. no. 81-1	Arnold and Weddle (1978: Fig. 16 (left))
[46]	*San Juan*	Wignall (1973, pp. 468 and Figs. 2a, 3)	N/A	Wignall (1973: Fig. 2a)
[47]	*Santa Maria De La Rosa*	Wignall (1973: 468 and Figs 2b, 4); Wignall (1982, Fig. 2b)	N/A	Wignall (1973: Fig. 2b)

(continued)

Table 12.1 (continued)

Anchor Frame Reference ID	Site Name	Citations	Object Identifier	Traced Line Drawing Citation (Fig. 12.1)
[48]	*Santa Maria De Yciar* (?) - Padre Island	Arnold and Weddle (1978: 212, 224, Figs. 15, 17 and tbl. J.1); Keith (1988b: Fig. 9)	N/A	Arnold and Weddle (1978: Fig. 15 (left))
[49]	Serçe Limanı A	Van Doorninck (Van Doorninck 1988, 2004)	An 1	Van Doorninck (2004: Fig. 12.5)
[50]			An 2	Van Doorninck (2004: Fig. 12.6)
[51]			An 3	Van Doorninck (2004: Fig. 12.7)
[52]			An 4	Van Doorninck (2004: Fig. 12.8)
[53]			An 5	Van Doorninck (2004: Fig. 12.9)
[54]			An 6	Van Doorninck (2004: Fig. 12.10)
[55]			An 7	Van Doorninck (2004: Fig. 12.11)
[56]			An 8	Van Doorninck (2004: Fig. 12.12)
[57]	Tartous	Tanabe et al. (1989, pp. 39 and site plan, C1)	N/A	N/A
[58]	*Trial* (?)	Green (1977a, pp. 1, 42, 50–1, 56 and Figs. 2, 4, 13, 15)	cat. no. A1	Green (1977a, b: Fig. 15, A1)
[59]			cat. no. A6	Green (1977a, b: Fig. 15, A6)
[60]	*Vergulde Draeck*	Green (1977b, pp. 64–5, 72, 90–1, 293 and Figs. 12, 15)	Green et al. (1977a, b: Fig. 15, no. 18 upper)	N/A

2 Iron Anchor-Frame Size, Beam Construction, and Technology

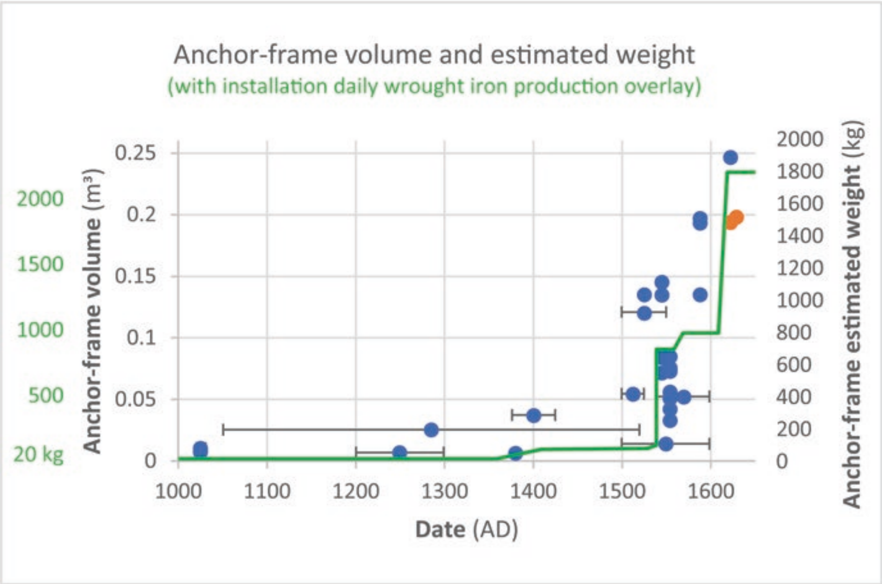
There is a noticeable increase in the size of anchor frames commencing from the mid-second millennium (Fig. 12.4), a factor based both on construction methodology and architecture of the shank and arm(s)-beams but also accessibility to wrought iron. The iron employed would have been wrought iron since cast iron is inadequately fragile (cf. Duhamel Du Monceau 1764, p. 11). Frames through the first quarter of the second millennium were likely constructed of iron fully manually produced, perhaps limited to itinerate smiths, moving to wherever was the specific need, and therefore there was little permanent infrastructure employed. Permanent furnaces, increasing in efficiency and size, may only have appeared in the thirteenth and fourteenth centuries (Gay 1997, p. 87).

A general understanding of the economics and technology of iron production from the fourteenth into the eighteenth century can be weaned, particularly, from Schubert's synthesis of the increasing daily potential output of iron from individual English installations[1], based on contemporary documents (Fig. 12.4; Schubert 1957: app. 4, cf. Gay 1997: app. 3 and 4). While waterpower had been employed for other purposes previously, Schubert demonstrates that the effect of the adoption of the waterwheel-powered bellows for the iron furnace on production is first recognizable at the beginning of the fifteenth century. Specifically, the potential heat and size of the furnace greatly increased allowing for significantly larger blooms – near 6-fold,

Fig. 12.4 (continued) indication of frame size, but **b** allows for significantly greater sample size since its two basic measurements are more regularly recorded than beam robusticity. The wrought iron maximum daily production from individual installations overlay is primarily based on English historical documents dating from CE 1330 (after Schubert 1957: app.4). Taking into consideration Stech and Maddin's (2004: 193–196) estimate that the limitation was about 25 kg for early simple bloomeries, the earlier limit into the fifteenth century is considered 20 kg, a few kg greater than Schubert's AD 1330–1360 documentation suggests, **a** Chronological scatter graph of an estimation of frames' iron volume, derived from the lengths of the arms and shank multiplied by the central shank section, along with their estimated weight. The data derive from : [1], [2], [9], [13], [24], [25], [26], [29], [30], [31], [32], [33], [34], [35], [36], [38], [39], [40], [41], [42], [43], [44], [45], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], and [58]. The points in orange are frames [3] and [59] which, since they lack document of the central shank section, have been estimated based on the central arm section instead. The estimated weight derives from the volume of the bars multiplied by 7.7 g/cm^3 following Light (1990: n.6). Since the latter bundled-bars tradition constructed frames would not have been entirely solid iron, their weight estimate based on overall dimensions should only be considered a maximum, **b** Chronological scatter graph of frame size based on shank beam length and arms-span determined by calculating the area of an oval defined by arms-span and shank height measurements. The data derive from : [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [30], [31], [32], [33], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], and [60].

[1] Technically the data informs of daily output, but Schubert assumes this equated to individual blooms, for which supporting evidence is provided.

a



b

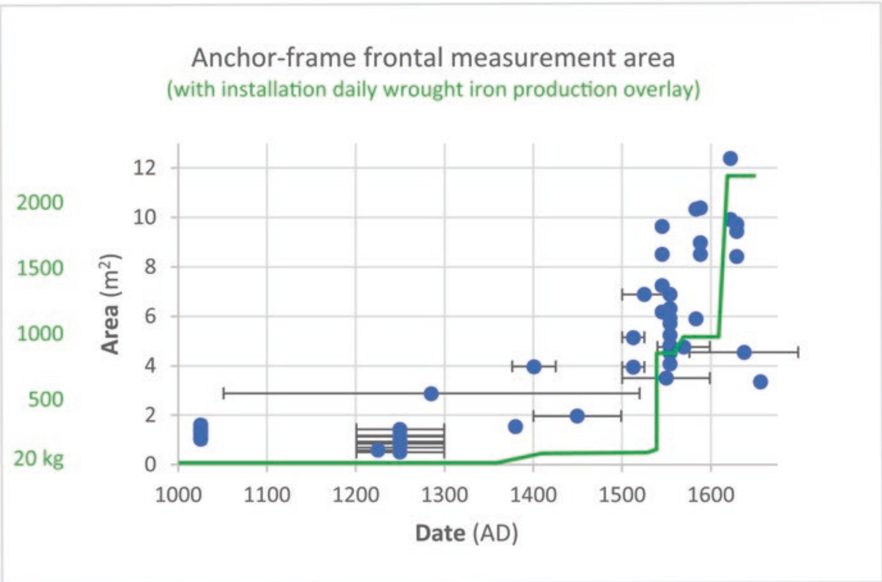


Fig. 12.4 Two calculations of anchor-frame sizes, both overlaid by evidence of iron installation daily wrought iron production. Only frames which have contextual date ranges less than 500 years are included, with the imprecisely dated displaying date-range bars. Chart **a** is a more accurate

from some 16 kg prior to *ca.* 90 kg blooms (Schubert 1957, pp. 139–140). The automated bellows would also allow for more efficient reheating in a chafery for better refinement and workability of the increasingly larger iron masses.

However, a particularly dramatic increase in production commences in the second quarter of the sixteenth century with a further potential 10-fold increase in the size of blooms (Schubert 1957, pp. 148–9). A novel technique of wrought iron production had been imported from northern Europe, perhaps specifically, now, Belgium since it gained the moniker the “Walloon process.” This technique is characterized as “indirect” based on the production and subsequent unique refining of cast iron blooms (cf. Gay 1997, pp. 257–60). Essentially, the temperatures that could now be achieved in the furnace were high enough to produce substantial cast iron efficiently. However, the ingots produced (known specifically as “pigs”) were too friable, due to high carbon content, to be wrought. Therefore, a discovery was necessary in which by blasting the pig with hot air in a uniquely constructed furnace with incorporated powerful bellows (a “blast furnace”), the blasted air would create a chemical reaction removing the excess carbon and the pig would disintegrate into drops of wrought iron which would coalesce on cooling into a mass called a “loupe.” The loupe could be refined and worked as wrought iron blooms had been for two millennia, on reheating under hammer/sledges (Fig. 12.5). With the adoption of this “Walloon process,” limits were again surpassed resulting in the great leap in potential iron production observed in the middle of the sixteenth century.

These developments in wrought iron production correspond reasonably well with the pattern of increasing sizes of anchor-frame finds towards the seventeenth century. Examining, specifically, frame size from the commencement of the second millennium (Fig. 12.4), this seems to demonstrate a modest increase by the fifteenth and early sixteenth century, reasonably following the adoption of the water-powered bellows and other furnace related developments in wrought iron production. Subsequently, in the middle of the sixteenth century, a dramatic increase is visible which is contemporary with and can therefore be hypothetically attributed to, the Walloon process. Improvements in the efficiency of machines, architectural furnace and slag extraction adjustments, and other complex factors such as flux additions and fuels, account for the continuing increases in production testified in the latter sixteenth century and beyond, which would, in turn, similarly benefit and enable larger anchor-frame production.

Regarding specific anchor-frame size, at the commencement of the second millennium, frames may have been limited by economic, technical, and cultural factors to those manually maneuverable. Considering also state documentary evidence, between the thirteenth and early sixteenth-century half-ton frames had become feasible. Thirteenth and fifteenth-century Italian documents testify to weights that max out at about 475 kg (Jal 1841; Champollion-Figeac 1843; Long et al. 2009). Significantly greater frames, even weighing over a ton, may first have been economical around the middle of the sixteenth century. An exception is documentation of anchors weighing over 500 kg, even a ton, from 1337 and 1420 English royal inventory records (Friel 1993, pp. 9–10, 1995, pp. 124–5). Following these, Friel suggests that the ability to make massive anchors commenced in the first half of the fourteenth century (1995, p. 127), a century prior to the pattern demonstratable here. The discrepancy between these two datasets is conceivably one between exceptional royal means and ordinary practicality.

Determining the effect of technological developments on anchor-frame architecture remains largely speculative since there have been only limited investigations of the workmanship of shank and arm-beams of finds. For the earliest centuries of the second millennium, we must commence with the better studied Mediterranean evidence. The rounded-shank robust-beam frames of the Serçe Limani and Çamaltı

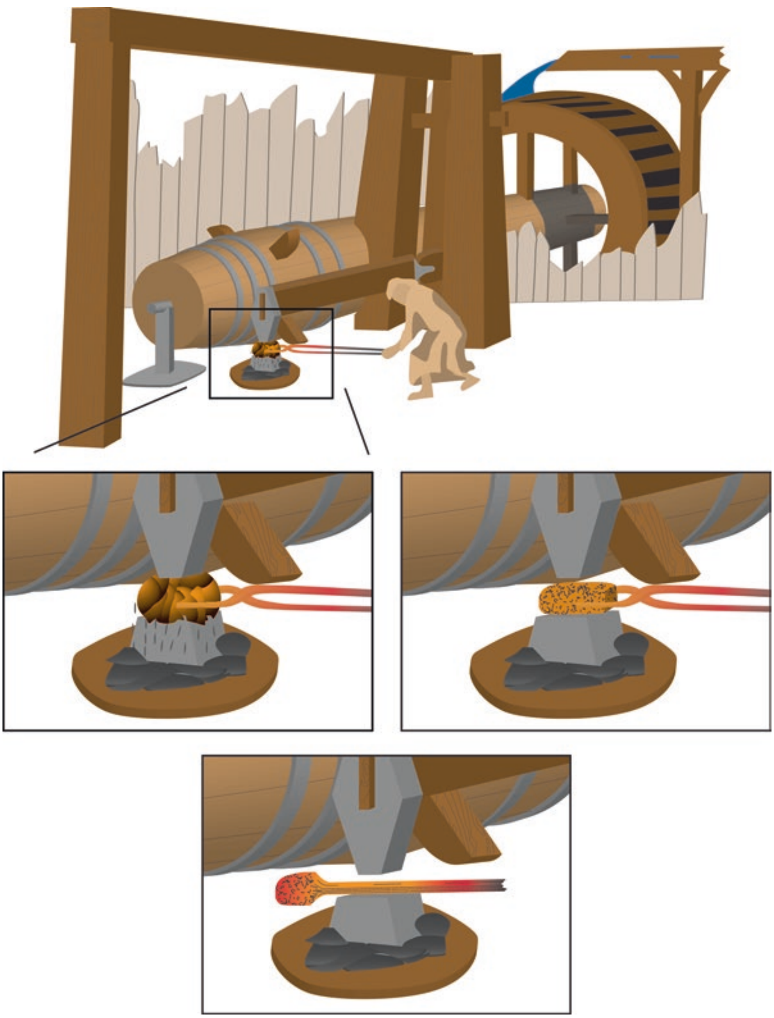


Fig. 12.5 Trace-based illustration of the creation of iron bars from a loupe with a waterwheel-powered mechanical hammer, based on sketches of a François Trésaguet authored 1702 French manuscript. (Archives Nationales AN.M. -D3 31.03/09; cf. Gay 1997: Fig. 101)

Burnu wrecks of the eleventh and thirteenth centuries display multiple weld marks demonstrating that the beams were formed by combining a dozen or so individual iron batons, each weighing around 5–6 kg (Stech and Maddin 2004; Van Doorninck 2004; Kocabaş 2008). Specifically, for the Serçe Limani, the batons are proposed to have been of standard dimension, *ca.* 24 cm x 6 cm diameter. Recognizing that simple furnaces could produce blooms considerably larger than the size of these batons, Stech and Maddin suggest that reheating technology at workshops was relatively simple demanding that the potentially original ca. 20 kg blooms[2] be cut into smaller pieces to enable preconstruction refining at coastal smithy workshops.

Despite the similarity in their date, and while also likely to have been limited to the combining of small iron pieces, we cannot however assume this exact method of construction for Viking frames, examples of which have yet to undergo invasive investigation. Rather, being of a northern European tradition with gracile rectangular shanks, their construction was possibly more similar to the *ca.* 1380 CE Bremen Kogge frame. The construction of its shank and arms-beams[3] are based on the tripartite combining of layers, oriented in the plane perpendicular to the arms, similar to lamination (Börsig 1981). Specifically, two beam-length *ca.* 30 x 20 mm section plates of iron sandwiched an interior section *ca.* 30 x 13 mm. This latter was not a plate but consisted of multiple individually attached pieces of iron which were preworked and welded on in such a way that the internal graining of the middle section ran perpendicular to the beam, opposite the graining of the two outer plates which ran parallel to the beam. The plates also differed from the interior section in having been made of nonphosphoric iron, whereas the middle section was heavily phosphoric. Ultimately, the beams were produced with a hard yet brittle interior but supple iron externally. This may have some similarities to Witsen (1671, p. 144) and Van Yk (1697) who suggest the combining of iron from different sources for anchor frames according to the iron's characteristic and expense. These authors suggest specifically that frames be forged with Spanish iron, which is tough but flexible, in combination with a rigid version, such as that from Sweden.

Most significantly, perhaps, is that the Bremen Kogge frame represents the earliest evidence of the lateral combining of long (beam-length) elements for the architecture of the beams. Its outer plates may be forerunners of subsequent centuries' use of long square-sectioned (previously rough small pieces) or rectangular-sectioned bars, which would become the common form of traded iron (Schubert 1957, pp. 129–30, 143, 151, 160, 162, 169 nn. 3, 172; Gay 1997, p. 260); and the practice of forging anchor frames with them is well supported (cf. Figs. 12.5 and 12.6a). De Reaumur (1764, p. 15) isolates important properties of bars for frames: The act of hammering out a narrow bar shape from the bloom forces much of the slag out, while bars can easily be cut to investigate their interior purity. In addition, producing a bar compacts the iron grains and remaining slag into longitudinal

[2] Stech and Maddin estimate that 25 kg blooms were possible for early installations, while Schubert's documentary evidence explicitly inform ca. 16 kg per day.

[3] Only the shank-beam was intrusively examined, but the arm(s)-beam also superficially demonstrates the same tripartite structure.

graining (cf. Fig. 12.5). For anchor frames, this property acts to strengthen the beam for which the bar is employed since the grains run along the length, whereas any grains running perpendicular to the run of the beam would be a fracture risk. Indeed, this longitudinal graining is apparent with the two Bremen Kogge plates. Concerning its phosphoritic central section, the perpendicularity of the grains and generally greater hardness due to the phosphorus would help fortify the crown-eye and head-eye piercing characteristic of early northern European anchors.

A related but distinct construction method and technique would appear by the sixteenth century. It is best testified by the Red Bay frame as examined and reported by Light (1990, 1992 pp. 249–53). In this case, three bars of similar length and uniform square section (ca. 2 m x 9 cm x 9 cm) were articulated; two for the shank, attached end-on-end with a single scarf, and the remaining bar was used as the arms beam; however, forge-bent headwards. As expected, it is evident that certain care was taken to forge the Red Bay's iron grains to run in the orientation of the bars. Novel, however, is the homogeneity, symmetry, and uniformity of the dimensions of the three bars leading Light to assume that they had been formed in a specialist forge of such bars (1990, p. 307). In order to distinguish this form of architecture from others (i.e., "laminated," "baton assembly," and "bundled-bars"—see below), this technique will be called here as "lone-bar" construction.

Light proposes that the design and feasibility of the Red Bay's bars were the results of efficiency and power resulting from waterwheel-powered heavy hammers. As substantiation for this possibility, in 1497 King Henry VII is documented as having commissioned iron bar stock forged by the *great water hamor* (Schubert 1957, p. 162), the earliest explicit reference to such a hammer. In the early sixteenth century, there is a reference to importing a design for a *martillo de agua* to Spain from Italy that would have also been used for bar production (Fernandez de Pinedo 1988, pp. 7–9). Indeed, the simple linear narrow rectilinear form of such bars would be ideal for refining and forming by the heavy automated hammer. Therefore, it is possible to suspect that the employment of bar stock for lone-bar construction of anchors is in connection with the development of powerful automated hammers. The method of bar construction employing a large waterwheel-powered hammer continued into the eighteenth century when one is sketched in a French document (Fig. 12.5). Conceivably, certain forges had established themselves for the production of bars (for anchor frames or otherwise trade). The produced bar stock would be traded to smiths in coastal cities for assembly and final anchor-frame construction. This said, the efficiency and power of early mechanical hammers were conceivably slight in their early centuries and increased over time. Light (1990, p. 313) suggests that the *ca.* 9 cm x 9 cm section of the Red Bay example was possibly reaching the limits of its forge because slag that had not been worked enough was visible.

Because each bar was limited in dimension by certain factors, such as the size of the bloom produced in the furnace, it was necessary to attach bars end-to-end on the shank to produce the desired shank length. While the Red Bay's arm and crownward-shank bars' length appear to correspond, the headward shank bar was somewhat shorter resulting in the scarf being headward from the center of the shank. This is

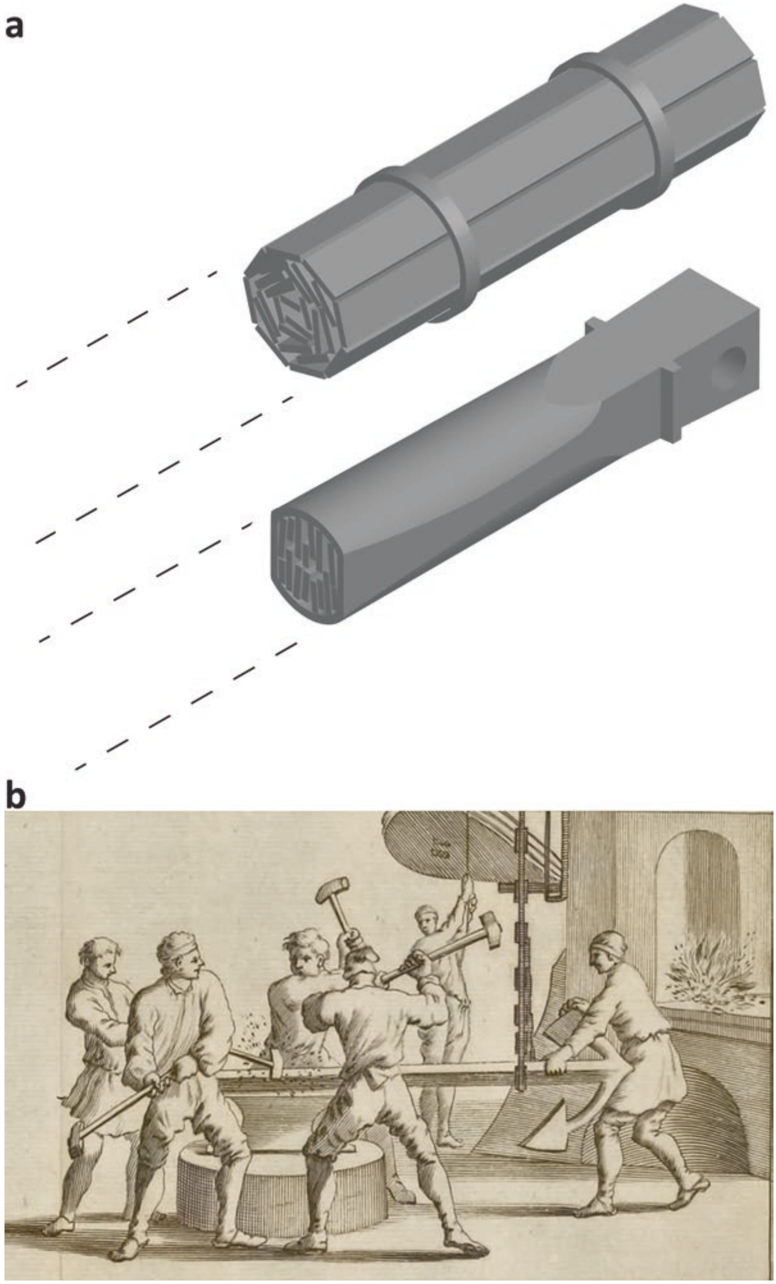


Fig. 12.6 Forging an anchor around 1700 CE, **a** Isometric illustrations of bundled-bar anchor beam construction sections, prior to and after forging. Based on two drawings in a manuscript dating AD 1705 (Gay 1997: 119 and Figs. 97 and 105), **b** A late seventeenth-century illustration of a team of four smiths sledge forging the shank of an anchor frame that is being manipulated with the help of a chain-winch into and out of the furnace by the master smith and another assistant (Van Yk 1697: foldout pg. 178, lower right)

feasibly the result of not only the bending of the headward bar to create the eye but also prior cutting shorter this bar to remove iron material for the ring, lugs, and the two flukes.

Despite only superficial recording, it is possible to propose the lone-bar construction for other frames as well. For the 1545 Mary Rose finds, one carefully illustrated frame ([32]) has scarf weld-like graining in roughly the middle of its shank. Two others are drawn with separations in the middle ([29] and [31]). Mc Elvogue also highlights only a single central shank weld for the *Mary Rose* frames in a generic drawing (2009, Fig. 15.9). Similar separations[4] at the shank are seen with three of the *San Esteban* 1554 wreck attribution ([39], [40], and [45]) and the Molasses Reef wreck finding of the first quarter of the sixteenth century. While it is not specified what caused these separations, it can be proposed that they are due to corrosion/breaking at the weld. A postdepositional slow disintegration of a poorly refined region of iron is identified by Light as the cause for a lower break in the Red Bay shank (1990, p. 313). Light further claims that these ([33], [39], [40], and [45]) and other frames of the 1554 wrecks assemblages ([36], [39], [41], [42], [43], and [44]) were constructed in the same tradition as the Red Bay (1992, pp. 251–2). He highlights that the beam sections are similar and that the head-eyes are designed the same, bent around rather than pierced (the so-called "gothic" finial), which would strongly support the identification of lone-bar architecture. It, therefore, appears that frames were constructed from three or so bars of bar stock, through most of the first half of the sixteenth century at least. That the well-rendered 1468 CE example on the altarpiece of Santa Ursula, Cataluña (cf. Casanovas 1993, photo 11) conspicuously matches with the common even curve bent bar-like arm's profile, symmetrically narrow and long shank known from the early sixteenth-century findings, may permit us to attribute the lone-bar type beam architecture back at least into the third quarter of the fifteenth century.

For the subsequent architectural development, we lack a specifically analyzed frame finding; however, hypotheses can be developed by considering later relevant documents along with consideration of changes in frame beam robusticity. French documents, which are both uniquely detailed and largely synthesized, provide illumination for the common construction of anchor frames around the later seventeenth and early eighteenth centuries (Gay 1997, pp. 115–33 and 131), when technical discussion of construction may be earliest found. One document of 1705 details that bars of 14–16 *lignes* (ca. 3.2–3.6 cm) square, ideally long enough to run the length of the intended beam, are carefully examined for imperfections and subsequently bundled and bound together by iron staple loops (cf. Fig. 12.6a). The bundle is subsequently heated and hammered to form by manual sledges (specifically weighing 12–15 *livres* (5.9–7.3 kg) with four *pieds* (1.3 m) long handles (cf. Figs. 12.6 a below and b). For English construction, there is less specific but complementary discussion (Merriman 1950, pp. 159–63).

[4] [39] and [40] are clearly recorded as fractures occurring prior to the wreck event. Possibly the weld was a relative point of weakness.

When this change occurred, from lone-bar to bundled-bar architecture, requires considerable speculation. Perhaps by the second half of the sixteenth century, the technique of bundling bars together and subsequently working them to create the frames' shank and arm(s)-beams was common since there are two unique form features of frames dating from this period. The first is that some beam finds demonstrate an increase in robusticity to around 250 cm^2, with the Armada wrecks ([25], [46], and [47]) and a first half of the seventeenth century find demonstrating a *ca.* 300 cm^2 section ([58]). Second is that the relative length of the shank conspicuously declines. The decline in shank length can be attributed to the inability to weld two sections of bundled-bars beam together, thus the smiths were limited to extending the bars before bundling them, ultimately resulting in relatively shorter shanks than typical of the first half of the sixteenth century. One possible frame ([48]) might specifically attribute the commencement of the bundled-bars architecture to *ca.* 1550 belonging to the *Santa Maria de Yciar* wreck of 1554. Its form is unique since its beam sections are rectangular rather than square (suggesting two bars bound side by side), the shank is relatively short, and its eye seems to have been punched rather than formed with "gothic" finial bending.

The bundled-bars architecture would be a logical response to the great increase in iron flooding the market as a result of the development of the Walloon process in the middle of the sixteenth century. Perhaps, the mechanical hammer had long reached its technical limits for the construction of bar stock, or feasibly it became impractical for anchor smiths to weld end-to-end a certain thickness of bars produced. The greater availability of wrought iron could not equate to more robust bars or their weldability. However, with the easing of economic factors, thicker beams could be wrought by bundling bars to whatever extent needed. With bundling, iron anchor-frames could now be produced to greater weights than previously and were less likely to suffer bending distortion, which is conspicuous with several sixteenth-century frames of lone-bar architecture ([36], [38] [39], [41], and [43]).

Although rounded, or partially so, shanks would become common later, the informative documentation of sixteenth and seventeenth-century frame findings suggest that they were constructed with at least roughly square (but with beveled edges) sections (cf. Fig. 12.6b). Therefore, we might presume that the bundles of bars would be layered with a similar symmetrical rectilinear section (rather than round) prior to working. Possibly, the ultimate robusticity of the frame would be determined by the width and height of the bar stock layers to be incorporated (3x3, 4x4, 5x5 …).

A Dutch note written in 1622 testifies that Spanish anchors were considered narrow, … *een heel dun Ancker ghelyck een Spaens-Ancker*, … (Van Nouhuys 1928, 1951, p. 44). Perhaps the Spanish were more lethargic in their transition to bundled beams architecture, or possibly the (supposed) suppler nature of Spanish iron was generally less likely to fracture, and their frames could therefore be made with narrower beams. This addressed, finds from the late sixteenth-century Spanish wrecks of *La Trinidad Valencera* ([25] and [26]), *San Juan,* and *Santa Maria de la Rosa* are among the most robust published. Smaller ship's anchor frames may have preserved the simpler lone-bar technique for longer.

How the arms were attached to the shank is also only moderately clarified. The arms of the Yassıada (Van Doorninck 1982) and Serçe Limanı (Van Doorninck 2004) were formed and hammer-welded separately, each to opposite sides of the shank at the crown. However, again, despite the relative chronological propinquity, we cannot assume the same for Viking frames, which have distinct designs. Sølver claims that the Ladby frame (1958, p. 297) was assembled by combining the shank beam with a second beam consisting of both arms, and conspicuously this also seems to be the case with the Bremen Kogge. This latter system was also demonstrated for the sixteenth-century Red Bay frame (Light 1990, 1992), in which the crownward end of the shank-beam was ... portion of the arms-beam (arms beam to shank-beam). The final welding was facilitated by a small enclosing patch placed on the face opposite the thin projection. Since frames built with the lone-bar technique have kept the arms-beam entire, without a scarf, this would be the natural scenario. Alternatively, bundled-bars architecture would have been more difficult to forge bend, which would have encouraged each arm to be constructed separately and individually hammer-welded at the crown (Light 1992, pp. 251–3).

Despite the great thickness that was eventually achieved, the scarce information that we have for the actual forge assembly of iron frames through most of the seventeenth century suggests that it could have been entirely manual. Although Schubert postulates that the water-powered hammer may have remained a novelty in the fifteenth and sixteenth centuries (Schubert 1957, pp. 137–8 and 147–8), this may have continued much longer for anchor assembly smiths. Late seventeenth-century French documents outline that despite considerable inquiry into constructing automated hammers for anchor-frame production in the coastal cities, their use remained limited to a single central region (Nivernais; Gay 1997, pp. 99–120). Automated hammers seem to have demanded a certain high sustained commitment of investment, a unique hydrographic regime, and were insufficiently versatile for anchor-frame construction. Correspondingly, Light notes for the Red Bay frame that it could have been assembled wholly by sledging (Light 1990, p. 309). Van Yk illustrates a large frame being sledged by a team of four smiths who are timing their hits in a continual synchronized manner, guided by a master smith, and maneuvered partially by a crane system with a chain manipulated by a sixth worker (Fig. 12.6b). With bundled-bar construction, manual hammering would ultimately find a complication since the bundles could only be worked to a certain depth resulting in a forged outer shell and unwelded interior bars (cf. Fig. 12.6a) but resulting concern for overly weak beams would only appear in documentation at the end of the seventeenth century.

Regarding the heavy beating necessary for the welding of the individual beams together, we learn of an apparatus used for forging frames as early as the second quarter of the eighteenth century which was an iron mass raised by human power and allowed to drop upon the preheated and placed shank and arm-beams, which would have had a particular benefit in the welding of the beams at the cross. Ultimately, through the seventeenth century, forging frames from standard bar stock may have primarily or entirely utilized a sledging-smith or sledging teams. Therefore, it appears that producing the base bar stock for frames could have been the only use of the water-powered hammer in anchor production, while the frames' final forming and assemblage were manual.

Of course, larger anchors would require greater labor and therefore increased relative cost. Fournier (1643) provides modest evidence stating that the price of *grands ancres* cost 24 *livre* per 100 lbs and 18 *livres* for *petites*. It would go without saying that larger frames, independent of the greater iron and fuel necessary, are more difficult and labor demanding to produce. In this case, it appears that larger frames were considered some 1/3 more expensive to produce than smaller ones. However, subsequently, technological demands on larger anchors may have increased expenditure significantly since late seventeenth-century Dutch (Gay 1997, p. 95) and early eighteenth-century English (Sutherland 1717, p. 141 and 144) documentation give figures around 2/3 to twice more expensive.

The first known experiments in testing the resilience of anchor frames before deployment, particularly relevant considering that interior voids and otherwise imperfections were practically imperceptible, took place by the end of the sixteenth century. A Dutch legal document dating from 1591 quoted by Van Yk (1697) as still valid in his time, states that all frames, independent of size, must be tested for durability before consignment. Specifically, they were suspended crown downward two feet above an iron surface and dropped (Witsen 1671, p. 143). The earliest evidence for such drop-testing in France derives from a 1706 document (Gay 1997, pp. 133–6). However, the drop test would find its end after coming into uncertainty with debates of how high the frames would need to be dropped from and rendered impractical with claims that they are merely damaging to frames that would otherwise be functional. England Royal Navy records of 1703 include the testimony of several smiths that such testing is misleading, they rather suggest that proofing be done by pulling horizontally with a winch (Merriman 1950, p. 163).

3 Conclusions

This investigation allows general hypotheses to be developed regarding important changes in iron anchor-frame production in the second millennium CE through the latter seventeenth century. Wrought iron and iron-anchor production was likely entirely manual through the millennium's earliest centuries, based on traded pieces cut weighing fractions of ca. 20 kg blooms, deriving from installations of ephemeral nature. At this time, at least two techniques of anchor construction were likely employed contemporaneously. In the Mediterranean, several small truncated iron batons were attached to each other end-to-end to produce shank and arm beams. In northern Europe, possibly the tradition was construction with thin and long plates, some with distinct content (e.g., phosphoritic), which were combined in a lamination-like manner.

The earliest significant changes to these traditions, commencing in the late fourteenth or early fifteenth century, were revolutionary. It is likely, primarily, waterpower bellows technology that resulted in some 4–6 times larger blooms, along with the invention of the water-powered hammer. The relevant installations would have been established inland both near where ore was mined, and where there was a uniquely active hydraulic regime (high-flow streams), for channels, or filling artificial ponds that could be emptied through channels, with waterwheels to power the large and sophisticated bellows necessary. Concerning the water-powered hammer, while specific evidence from the crucial fifteenth century is limited to its final decade, we can propose that the water-powered hammer appeared by the middle of this century. The automated hammer would produce stronger and sustained power to convert the increasing in size blooms into standardizing iron bars for cart and riverine transport distribution to workshops on the coast.

It may have been rapidly recognizable that these bars alone, with only minimal additional refining, were suitable for the beams of anchors. Particularly, they may have been better priced, purer, easier to check purity, and arrive with graining running along its length, this latter saving substantial smithing labor. Even when attaching the bars end-on-end for larger anchors, the final beams would contain fewer, for baton assembly architecture much fewer, welds. Manual sledging harbor smith teams now constructing with long standardized and robust premade iron bars, preliminary refined, could more easily, and likely cheaper in materials and labor, produce larger anchor frames in dimension and weight. Such novel changes in anchor-frame construction and size may very well have helped catalyze the novel confidence in sailors to explore uncharted regions that characterizes the end of the fifteenth century.

If a (potential) fifteenth-century appearance of the water-powered hammer resulted in a novel culture of nautical discovery, the second quarter of the sixteenth-century Walloon process ensured its sustainability and expansion to globalization**.** The Walloon process dramatically increased further wrought iron and bar production, and anchor beams could increase in girth (and thus strength) by smiting them with multiple bars prebundled together. The Walloon process may be responsible for the doubling of the practical weight limitations of anchor frames in the latter half of the sixteenth century (i.e., from *ca.* 500 kg to a ton or more).

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Chapter 13
A Shared Sailing: Artillery and Ocean Warships

Francisco Javier López Martín

Abstract The work focuses on the study of the different types of cannon used during the first decades of the sixteenth century and the reforms that had to be carried out on ships to be able to accommodate a greater number of larger and heavier cannons. A special emphasis is made on carracks and the first uses of gunports in the Mediterranean Sea, especially during the Naples wars at the end of the fifteenth century. The Mediterranean was the main area where the use of guns and fighting between fleets was developed.

1 Introduction

Ships probably started using firearms in the mid-fourteenth century, shortly after they were invented and began to be used in land sieges. There are few iconographic and documentaries sources that allow us to know precisely the artillery—forms and materials—that armed medieval and early modern ships. However, ships were modifying their lines as the artillery increased its power. The research that has previously focused on the evolution of warships has not studied, in-depth, the impact that guns had on ship modification. When thinking of a ship armed with artillery, we must consider that the types of guns could be all the same and not necessarily different. This is important when the shooting rate and charging methods are discussed. When the size and effectiveness of the artillery increased, its manufacturing process became specialized and there is no doubt that in the Modern Age gunfounding became a semi-artisan production or, what is the same, semi-industrial process.

Therefore, the current orthodox opinion was—even today is—that: (i) Individual cannon were "one-offs" before the eighteenth century; (ii) The technology available from the fifteenth century onwards was not conducive to repeatability, and (iii) There was no mass production system. However, recent studies have shown that this is not true. Following a pattern, the guns did not have to be all different ("unique"), the system could have reproduced as many copies as needed ("repeatability"), and consequently this would suppose a new production system ("mass production" or

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“repeated production”), even when parts of the process were artisanal. Thus, prior to the eighteenth-century artillery gunfounders were ready to use repeated production techniques and were able to cast identical guns. In other words, it is standardization. The problem to achieve a complete standardization in artillery came from the lack of uniform measurements—the case of the Spanish empire and other crowns—and from bureaucratic problems of the central powers (López Martín 2011).

Through a real-scale drawing and the strickle board, the gunfounders could make as many identical pieces as they needed. The lost wax method was never used in the manufacture of artillery because the mold was destroyed during the process, having to start from scratch every time a new gun was made, and the system would have been slow and extremely expensive. However, the system based on the drawing and the strickle board allowed the reproduction of as many clay copies as necessary to produce hollow molds from them. The strickle box for casting allowed the work division in the gunfoundry. This was more evident when the guns commissioned were the same and the gunfounders had to produce the same pieces in shape and caliber. With this system, the master gunfounder could make more cannon in a much faster and cheaper way. Copies could be reviewed by workshop apprentices while the master could focus on new designs or new assignments. Calibers could be regulated even since the fourteenth century. During the second quarter of the sixteenth century, the caliber stick allowed equal proportion for stone, lead, and iron ammunition with weights from one pound to 100 pounds, so the gunfounder previously knew the exact dimensions that should be given to the calibers. A different problem, but closely linked, was the unification measures, which affected more than one territory, for example, those governed by the Catholic Monarchy. Even so, in a wider view, this method can be understood as a semi-mass production system or repeated production system. It has been ensured that only from the eighteenth century onwards cannon were cast with the same molds. This is not true. Gunfounding—and the arms industry in general—sought from the beginning the quickest and cheapest way to duplicate the pieces produced. It was an indisputable advantage to have a ship armed with identical cannon, of equal caliber and that could use the same ammunition.

It is not the purpose of these pages to answer why it has always been thought that there was no repeated production in artillery, or why all gunfoundries under the same power did not manufacture the same types of pieces of equal measurements and calibers, in each series of cannon cast, so that the ammunition of each type would fit them. These issues have been studied in other works (López Martín 2011). It is, however, to establish guidelines for the use of artillery on ships, guns that for a long time were the same as used on land. To try to create a common lexicon of ancient artillery in each language (e.g., Spanish, Portuguese, English, French, etc.) is nonsense. Vanoccio Biringuccio was not at all interested in comparing cannon names already in 1540. Therefore, specific cannon names will not be used here beyond “cannon,” “culverin,” “bombard,” “swivel-gun,” and little else. Likewise, demonstrating where and how the cannon were used for the first time, or the successful use of broadside gunnery is also outside of the scope of these pages.

2 Types of Artillery and Ships

The first cannon might have been cast in bronze. The bronze casting needed a master gunfounder to shape the mold and then mix and melt the metals, proceed to cast at a very high temperature, and review the piece by hand once cooled. Even with only one master, the casting process required heavy economic investment and a large number of assistants in each of the stages, making the final product more expensive than the forging of iron. Copper and tin also had a higher price than iron. However, even being the final product was more expensive, bronze cannons were used for a longer period of time. Andrés de Espinosa, a gunner from Seville, said so in 1576 when, in the dialogue he wrote for the examination of young pupils, he claimed that a piece of bronze was more valuable than a piece of iron "not only because the metal is more expensive, but also because it is safer to shoot," especially if the metal was meted with the appropriate alloy (Fernández Duro 1881).

Bronze cannons were made for both muzzle loading and breech-loading. Either construction techniques or the way to shot were affected by the type of material. A muzzle loading gun consisted of a closed tube in its later part, that did not allow gas to escape and use all the force of the gunpowder in order to achieve a more powerful shot to a greater distance. For this reason, a bronze cannon was much safer than a wrought-iron one made in two pieces. It also was more durable. Bronze cannon, which had gone hand in hand with the development of the artillery since its invention, were used to arm ships. However, throughout the fifteenth and early sixteenth centuries, the problem to ship them was the weight, because, with equal dimensions, a bronze cannon was much heavier than a wrought-iron one. This affected both the ship structure and its stability. Another problem arose when using muzzle loading guns since their firing required a great number of tools for cleaning and loading. Breech-loading was faster. For this reason, bronze cannons were also made breech-loading in two adjustable pieces, the chase, and the chamber. The projectile used was usually iron.

Wrought-iron was used in the manufacture of artillery due to its lower economic cost: a forged piece was cheaper, usually faster to produce (depending on the size), and needed fewer qualified gunners. For this reason, iron was used for the manufacture of artillery at the early stage. However, the iron working technique forced to make slightly different pieces, because while the bronze was melted and shaped in previously prepared molds, the iron had to be worked hot with the hammer to shape it at the forge. The most common wrought-iron pieces used in ships during the fifteenth and sixteenth centuries were bombards and swivel-guns (no matter now the names given to them in each country or European region). To make the piece by the standard method, the master smith used a wooden armature, the length of the proposed cannon, to form the core of the barrel, surrounded with longitudinal bars of iron or *staves*, fixed rigidly. Red-hot iron bands were added over this structure at right angles to the axis. When quenched, the bands contracted to pinch the staves together. The grip was sufficient to withstand the discharge of gunpowder. The larger the piece the more bands were needed. In an alternative way of constructing the barrel, instead of longitudinal staves, a single or two wide iron strips of the length of the barrel were clamped together into a tube and then braced externally by the bands. However, it seems that these structures would hardly stand a powerful gunpowder explosion and they only appear in small pieces (López Martín 2011). Due to the bars and staves technique, the wrought-iron pieces could not be loaded with heavy amounts of gunpowder because they could explode due to a failure in one of its numerous joints. Excessive heating by continuous firing was the main problem of an artillery gun. Since the chase and the chamber were two independent pieces, there was a loss of pressure in this type of piece, which led to reaching smaller ranges. A large bombard was tremendously heavy and the absence of trunnions on it forced to keep the piece secured by ropes to a “box” or primitive carriage, usually a pair of thick and sturdy boards arranged at right angles able to absorb the strong recoil produced when firing. These carriages had solid wheels and progressed into spoke wheels. Iron cannon used stone ammunition due to friction in the bore. All these features discouraged wrought-iron guns. They had another disadvantage. A shot fired with a bronze piece could exceed 500 m/sec, while a shot fired with a wrought-iron piece could barely exceed the speed of sound, 340 m/sec. These results were obtained in shooting tests made with modern replicas of original pieces recovered from the *Mary Rose* (Hildred 2005). The average range of bronze pieces was between 1000 and 1500 m or even more, but its maximum effectiveness was between 800 and 900 m depending on the type of piece, the material (and therefore the weight), ammunition, and last but not least, the gunpowder composition. The optimum average range of wrought-iron pieces was between 500 and 800 m. Presumably, original pieces loaded by experienced gunners with powerful gunpowder charges could reach significantly higher speeds.

The Vasa Museum has also carried out firing tests with a replica of an original 24 pounds gun recovered from the *Vasa*, sunk in 1628. Different shots were fired against a reconstruction of the *Vasa*’s hull section at the level of the lower deck of 4 × 3 m and 75 cm. thick, oak made, and similar dimensions as the original, located at 35 m. The projectiles penetrated the target as if it was paper in 99% of the cases with an accuracy of centimeters. Only one projectile did not pierce the target due to the lower powder charge with which it was fired. Every shot produced a large, dense, cloud of smoke that impeded vision. These tests give a reliable testimony of the power of the artillery used in ships (Dr Mårten Granberg, Vasa Museum, pers. comm. 2014). The Museum staff of the Danish frigate *Jylland* has carried out the same type of test with similar results.

These were the reasons for first using bronze guns and then cast-iron artillery. Wrought-iron pieces did not stop being used for being outdated, except if one considers that its manufacturing technique was obsolete in comparison with monobloc bronze tubes. When the Spanish gunner Luis Collado criticized forged iron guns in 1586, bronze pieces had surpassed those of wrought iron, and cast-iron ones began to overlap those of bronze. It was purely a matter of technological challenge, and the change was gradual. It has not been found a way to form a typology based on technical construction or metallurgical criteria for wrought-iron pieces because they were similar throughout Europe and each master or workshop gave his personal shape to the pieces if particular designs had not previously specified by the Crown, as standardization also affected the wrought-iron artillery. An attempt to form a typology is the study from stylistic criteria, for example, of the shapes given to the lifting and reinforcement rings, since they can form groups that indicate the workshops which forged the pieces since there were no different masters, or workshops, working with the same forms. This feature did occur throughout the continent. Thus, the shapes of lifting rings that the masters or workshops that made the wrought-iron guns for the *Mary Rose* are not the same as those that the masters or workshops made for the conquest of Granada by the Catholic Kings. There is no much research on master or workshop marks, especially in swivel-guns (López Martín 2011).

Swivel-guns—either in bronze or iron—were smaller pieces than cannon and bombards, both in length and in caliber. They could be built with the bars and staves technique or in a single cast piece. They were also breech-loading pieces with the difference that their chambers were not simply adjusted to one end of the chase, but had to enter in the main body at a certain angle and then fix them on the back by a lock or latch. Since they were breech-loading pieces they did not need to be introduced inside the deck to reload, because it was easy for the gunner to reload the gun from the rear end of the breech. Logically it was a great advantage over the muzzle loading guns. Swivel-guns were mounted on deck in a hook. They used stone or lead ammunition and occasionally shrapnel and their use was anti-personnel. Like all breech-loading parts, rotating pistols expel gases upon combustion that can cause a loss of power. Its average range was between 300 and 500 mt. Swivel-guns were used on ships until the eighteenth century. Breech chambers were used as modern cartridges, allowing a higher rate of shot, as the gunner only needed to change one chamber for another. The breech chambers, independently of their material, fitted precisely to the piece and formed a set. This was extremely important when it came to unifying calibers since all the pieces of the same caliber used the same type of chamber and were interchangeable. This increased the rate of fire. Guns, chambers, ammunition, and even the loading and cleaning tools were frequently marked with a special sign that identified them. Standardization was systematically sought since the fourteenth century (López Martín 2011).

The manufacture of artillery from cast-iron required much more complex technology than bronze, and its use was very limited until the gunfounders reached the temperature necessary to melt the iron and the method became cheaper. Since the late Middle Ages, the new blast furnaces could achieve significantly higher temperatures (around 1450 °C), which facilitated a higher absorption of carbon in the metal, and much more efficient exploitation of the ores. As a result, castiron became a widely accessible and cheaper alternative to bronze. In sum, depending on the period, technological knowledge, and expected technical requirements of the resulting metal, iron guns could be made by either welding together pieces of bloomery or wrought iron by hammering in the solid-state, or by directly casting liquid high-carbon iron into molds. Cast-iron cannons are documented during the first 30 years of the fifteenth century and were already used in Danish ships in the second decade of the sixteenth century. When the blast furnaces technique was improved it was possible to melt iron artillery much cheaper than the bronze one and to an unprecedented scale. It was the reason why the fleets began to arm their ships with iron cannons (López Martín 2011). When talking about ship-borne artillery, it is also necessary to take into account the period, the geographical stage, the manufacturing technique—the material with which it was made—and its dimensions, since all these factors were decisive for its use. It is not the same to deal with large castings as with small wrought-iron pieces, as both were used at the same time. Both manufacturing techniques and dimensions varied over time and were used in an overlapping manner, so there is no need to attempt to categorize material-based, nor ask when gun improvements were made that allowed them to be placed onboard.

Finally, it is necessary to point out the fact that cannon had a great commercial value. This was due to both its value as a weapon of war and the economic value of metals, especially bronze guns due to their high resistance to corrosion. Bronze guns could be melted again in new pieces of modern designs. Resistance to corrosion is the reason why many shipwrecks lack bronze cannons. The recovery in situ of bronze artillery from a shipwreck was a priority action if its location was known and the remains were not sunk at great depth. The lack of bronze cannon which is frequently found in shipwrecks should not lead to thinking that ships were armed mostly with iron cannon, or even that they did not have bronze cannon at all. These were the first to recover.

3 Changes in Ship Shape

Fourteenth-century cannon were of small size and their effectiveness was very reduced both in campaign and sieges to fortifications, but the everlasting war between the European crowns made the firearms progress spectacularly fast. Corned or granulated gunpowder favored a variation in the size of the pieces that were progressively increased since the end of the century. When better gunpowder combustion was achieved due to the corning process, shorter powder chambers became feasible and the difference in ratio between chambers and barrels was reduced. When cannon with long barrels turned out to have a greater range due to an increase of the ball velocity in the bore, not only was the cannon shape modified but targets could now be attacked with new confidence. The first half of the fifteenth century was the period of giant guns, with 50 cm caliber or more. The size increase was supported by the idea that the larger was the gun, the greater was the range. Therefore, the more destructive was the gun. Taccola's *De ingeneis*, completed in 1433, warns of the problem of making large pieces saying that a heavy bombard could not be transported by horses. Taccola's solution was the manufacturing pieces with detachable components and use oxen for their transport (López Martín 2011). In addition to these transport problems, such large pieces were impossible to mount on a ship. In the fall of Constantinople, the great siege cannon-train of Mehmet II played a determining role, but such pieces would have broken a ship in two.

The fall of Constantinople coincided with the climax in the techniques of iron forging and bronze casting in artillery. There are examples of these giant pieces. In wrought-iron the *Pumhart von Steyr* (early fifteenth century, ca. 8000 kg); the *Michellettes* (ca. 1423, 363 cm); the *Dulle Griet*—the largest European wrought-iron cannon in existence—(ca. 1448, 500 cm, 16,400 kg); or the seven breech chambers of 142 cm in length each, built before the middle of 1489, that the Catholic Kings took to the siege of Baza. Their barrels were lost during the Napoleonic Wars, but their calibers reached 46 cm and its total length was around 3 m, so each bombard had an approximate length of 450 cm. Outstanding bronze pieces are the Dardanelles gun—the oldest dated cannon in the West—(cast in 1464, 518 cm, ca. 17 tons) and the *Schöne Katharina* (cast in 1487, 365 cm) (López Martín 2011). In 1869 a great Turkish siege gun was fired three times in a trial and the shot distance reached was 5.2 km. With cannons like these, the Ottomans conquered Eastern Europe and the Catholic Kings took Setenil after 15 days of intense bombing. Nevertheless, these pieces were a technological dead-end. Changes would occur in the development of cannon shape, but the construction technique remained the same. The limitations of the forge restricted its role and evolution. Cast-iron artillery had less impact on European warfare at the dawn of the Early Modern period, as the casting technique was problematic. However, bronze was soon the preferred material for warlike sovereigns who perpetuated in casting their status, mottoes, and heraldic bearings. If it was well cast bronze, an alloy of copper and tin, was more resistant than iron, which soon corroded when exposed to the air, and more important, bronze could be re-cast with new designs as many times as necessary (López Martín 2011).

During the second half of the fifteenth-century artillery in Western Europe developed in a different direction: smaller dimensions and calibers combined with maneuverability and easy transport. This led to cannon proliferating all over Europe. The political powers sought to achieve this in the shortest time possible. These pieces already existed, but now they became predominant. It was a great difference. France and Burgundy took the lead in this development and Portugal were not far behind. Diebold Schilling's chronicles completed during the 1470s and the 1480s confirm the use of smaller, more maneuverable artillery mounted on two-wheeled wagons pulled by horses instead of oxen. It was the type of artillery that Charles VIII of France had placed in Tours in 1488 (when Duke Francis II of Brittany died) prepared for the annexation of the Duchy of Brittany. It is known thanks to the spy reports sent to Spain to Ferdinand the Catholic. Examples of this type of piece have also survived (López Martín 2011).

It is evident that giant bombards could not be mounted on a ship, but pieces of smaller dimensions and calibers. However, during the second half of the fifteenth century, it was still not possible to mount a large number of guns, since their weight exceeded that which could support ship structure. For this reason, the structure had to be adapted to the guns. The strategic need to use large-caliber and size (but not giant) cannon onboard ships became a driving force in Renaissance shipbuilding (Zwick 2016). In other words: in the close relationship between shipbuilding and gunfounding, it were ships and not cannon which had to increase in size (Alcalá-Zamora y Queipo de Llano 1974). Thus, it seems clearly true that armament altered both tactics and warship construction long before the 1530s (Rodger 1996).

For a long time, cannons used in the ships were not different neither in the form nor in the material of the guns used on land. Muzzle loading bronze pieces were more difficult to load and weighed more than wrought-iron guns, for which to build a ship with large and numerous pieces of bronze was supposed to alter considerably its stability and balance and therefore its navigability. The total weight of the artillery was limited until the end of the fifteenth century when the shipbuilding technique managed to develop ships of a size and design that allowed them to sail on an oceanic scale, and modify their structure in order to achieve the use of a considerable number of cannon. The bombardment from a distance of static (a fortress) or moving (a ship) targets in order to eliminate their offensive or maneuver capacity before taking it to assault or collision, was what motivated the change in shipbuilding (Adams 2013). Since the guns mounted on board were not all the same in design, weight, and measurements—because until well into the seventeenth century a ship was armed with all the available stock at the arsenals—, the total weight of the artillery—or, in other words, the sum of the weight of each gun—was random and, therefore, different for each ship or for each voyage. When ships continued to increase in size and the modifications made to their structure were again improved, their sides could be first assembled with fixed batteries of bronze cannon and later with cast-iron cannon.

Therefore, cannon design, weight, size, number, and loading method, conditioned ship shape, forcing important changes since these five factors—which are inherent to the evolution of the warship up to the present day—depended on the tonnage that the ship could support without endangering its stability (Hildred 2005). Ships had to be modified in order to allow for the increase in the number of powerful large-caliber pieces on board. Thus, the artillery forced the ships to modify their structure from the third quarter of the fifteenth century in the same way as it already had in the land fortifications at the beginning of the same century. Sebastián de Covarrubias' *Tesoro de la lengua Castellana o Española* (Cobarrubias Orozco 1611) defined a ship as "a well-armed castle of people and ammunition that moves through the sea" (Trejo Rivera 2005). When did these changes occur? Where did they happen? Did they arise spontaneously or were they motivated by each other? These are questions that are still to be answered, but these pages may be a new attempt to should shed some light on this issue.

The first change made to the ships was motivated by gun firing, an action that involved both loading and recoiling. Both factors forced to make a wider bridge in order to provide more free space that would allow the handling, easy loading, and recoiling of the pieces when fired. For these reasons, guns used in ships at the end of the fifteenth and the beginning of the sixteenth century were mainly breech-loading, which allowed loading without the need to move it from its firing position. The number of breeches varied depending on the rate of fire. The limited space on the deck made it difficult to load a muzzle loading gun. When it was fired, it had to be removed from its position in order to clean the residues that had remained in its core (hot traces of hot burned or unburned gunpowder, particles of the block, pieces of cloth, etc.). After being fired, it had to be loaded again with another ball and placed back in firing position. However, this difficulty did not prevent the use of heavy and long bronze pieces. Such pieces have been recovered from different shipwrecks. For example, two guns were cast between 1498 and 1510 for Johan Herze, mayor of Lübeck. They were mounted on the *Engelen* (second of this name) sunk in 1565. In the Venetian attack on Trieste against Emperor Maximilian in 1507, eight galleys and two ships [*naos*] were used, from which 20 pound balls were fired at a distance of 3000 steps from culverins and basilisks 20 feet long (5 m long cannon firing at a distance of about 4 km. (López de Gómara 2000). These types of pieces have also been preserved.

Gun recoil increased according to cannon size and its powder charge. The bigger the gun, the more gunpowder it needed and the more recoil it had. The Vasa Museum has carried out (Oct. 2014) firing tests with a replica of an original 24 pounds gun retrieved from the *Vasa* sunk in 1628. The tests began firing four projectiles, the largest of which weighed 3.3 kg. with a powder charge of 2.65 kg, which generated pressure on the chamber of 731 kg/cm^2 (10,400 psi) and initial velocities at the muzzle between 360 and 399 m/sec. The recoil distance of the barrel was 1.6 m, enough for the chase to retract and be recharged on the deck. Shooting tests were also carried out leaving the gun unattached: with a charge of 1.1 kg, the recoil was 1 m; with 2.2 kg. the cannon retreated 5.64 m; with 2.65 kg, 7.65 m; and with 3.3 kg, 9.5 m. When the cannon was retained it was tied to two one-tonne steel weights each with a five-centimeter thick rope. The results of these experimental tests give an idea of the tremendous force of gun recoil when it was fired. In the mid-sixteenth century, the Portuguese Fernando de Oliveira warned about the recoil of such large guns in small ships "*porqueosabrem e desbaratammuyto*" (Oliveira 1555). The concern about leaving free space around cannon is easily understood.

The second change or modification was to provide greater strength to the decks to be able to support the weight of the guns, which was increasing throughout the years. To the extraordinary weight of the guns was added the cargo of goods—excessive, badly distributed, and frequently increased illegally—resulting in fatal outcomes, especially when sailing with strong swells or facing powerful winds. Of course, the bigger was the ship, the more cannon could be mounted on her decks. But the increase in the number of pieces on the bridge and in the castles moved the center of gravity and endangered the ship's stability. The solution was to place the heaviest guns as low as possible near the center of gravity to avoid endangering the stability.

This resulted in a third and transcendental modification that changed the shape of warships forever: the creation of a long deck with open gunports at regular intervals (another variation of the castle loopholes) through which guns could fire, and equipped with lidded ports to open or close them. However, the weight of the artillery placed on the lower deck and the opening of artillery gunports in a long battery under the bridge weakened the structures of the hulls built with the clinker technique. The assembly of heavy and powerful guns on the top of round sterns did not need great changes, but it was even easier to place them in flat sterns or square finished sterns. In addition, placing the same guns in the lower part of the ship and firing from both sides of the hull required that the width of the battery where the guns were placed was carried to the stern, and in this case, it was also easier to finish in square or flat shape. In order to build that long battery and open gunports on both sides, it was necessary to reinforce the basic structure of the hulls, the beams, and the reinforcements to support the weight of the guns and their violent recoil. These modifications were a serious structural problem for a ship built with a clinker technique, in which the main tensions were transferred through the hull, so that opening a considerable number of gunports weakened it considerably. However, it was not a problem for a ship built with the carvel technique (Zwick 2016). This change was crucial for shipbuilding.

However, carrying cannon on the lower bridges to avoid disturbing the ship balance and the opening of artillery lidded gunports on the lower decks had an inherent risk of sinking since it required the gunports to be located dangerously close to the waterline. Gunports must be opened and close very quickly and be as watertight as possible once closed. Some ships sank because they could not close in time a gunport that had been below the waterline as the ship slinked beyond the critical point. The opening of such gunports on the side of the ships was a crucial addition. It allowed the change from carrying one or two guns during the fifteenth century to complete batteries of 112 guns or more in the eighteenth century. Until the eighteenth-century cannon were the same as those used in land sieges, because, broadly speaking, there was no regulated naval artillery. So basically the success of having heavily armed ships did not depend on the guns but on the ships.

Despite their tremendous importance artillery gunports have not been studied in-depth and there is no precise chronology for their first uses and subsequent development. The invention of gunports is usually placed at the beginning of the sixteenth century. Traditionally, its creation has been attributed to a French shipwright master who supposedly devised them at the beginning of the sixteenth century. However, in addition to being difficult for a shipwright to carry out such an innovation—as he would have no experience in warfare techniques or artillery science—, it is a statement that has no scientific basis based on reliable historical sources. Although its first appearance remains unknown, and it had to be a process of continuous evolution in shipbuilding, it is clear that someone, somewhere, had to have the genial idea. There is, however, reliable pictorial evidence that offers chronological patterns.

Gunports probably had to appear during the second half of the fifteenth century as an evolution of the loading and ventilation doors that were placed on the sides of the ship. These remained closed when the ship sails, while open in port they facilitated loading and the ventilation of the main deck. There are fine fifteenth-century examples of these doors. One is Beato Angelico's *Stories of St. Nicholas of Bari, three youths put into brine and St Nicholas saves a ship from sinking*, ca. 1437 (Vatican Museum cat. 40,252), painted for the chapel of St. Niccolò in the church of St. Domenico in Perugia. The table shows three ships, two of which have cargo and ventilation ports located near the stern. Another example comes from Antonio Pisano, *Pisanello*, who also dedicated himself to the design of war machines. He worked for Alphonse V of Aragon, King of Naples, during 1448 and 1449. It is very likely that his drawings of large cannons correspond to royal guns stored at the arsenal of Naples, which the French embarked on with the intention of taking them to France in 1494. Likewise, his ship drawings were not just Renaissance sketches of particular beauty and proportion but designs capable of being made, something of great interest to a Renaissance prince (López Martín 2011). There is a group of detailed ship designs from *Pisanello* or his workshop. Two of them had to be part of the same folio (Fig. 13.1). They have reduced castles to bow and stern. The side near the stern has a large opening or lidded port. The other smaller openings which can be seen aft, the chocks, were used to release the ropes to tie the ship up in port.

Pisanello's drawings were not isolated cases. The famous print of a Man-of-war turned to the left (Ashmolean Museum, University of Oxford, WA1863.2929) by the Master W with the Key—Willem Vanden Cruce?—, made for the Duke of Burgundy Charles the Bold ca. 1468, shows a three-masts carrack on the port side armed with small cannon and a large opening on its side (the engraving has also been dated between 1467 and ca. 1495). From about 1468 it is a drawing of the *History of Alexander the Great*, also made for the same Duke. It shows that the opening could also be occasionally used for rescue works (Fig. 13.2). In 1474 the *Amtliche Berner Chronik* (Official Chronicle of Bern) was commissioned by the city to Diebold Schilling, who between 1478 and 1483 submitted to the city's town hall a three-volume work with more than 600 illustrations showing events that occurred in Classical antiquity. There is a drawing within the first volume that shows the siege of a city in which the attacking army is using hand cannons and crossbows.

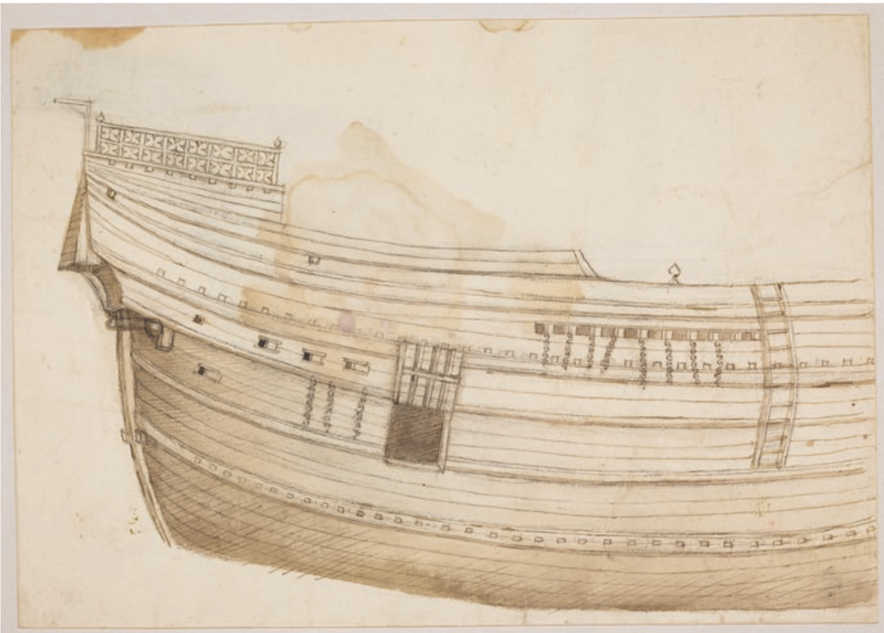

Fig. 13.1 Half hull of a ship by Antonio di Puccio Pisano, *Pisanello*. Codex Vallardi, mid-fifteenth century, inv. 2287r. Detail of stern with a large opening or loading gunport. (Source: Musée du Louvre. Photo © RMN-Grand Palais (musée du Louvre)/Michel Urtado)

Fig. 13.2 *Des Fais du grant Alexandre*, Quintus Curtius Rufus, 1468–1470, French translation by Vasco da Lucena (detail). An opening or loading gunport at the stern is being used to rescue soldiers. BnF, Ms. Français 257, fol. 39v. (Source: gallica.bnf.fr/BnF)

They are arranged behind a long wooden parapet with four open gaps at a regular distance. Such a structure does not differ from the section of a ship hull where the ports would be open. Another drawing shows a large bronze bombard settled on the ground and adjusted with a piece of wood to control the recoil. The gunner is about to fire the gun while another, who brings him a projectile, is lifting the parapet by a rope that protects the gunner, a protection that is exactly the same as lidded gunports used in ships.

What emerges from these drawings is that if these constructions and mechanisms were painted during the 1480s, it is true that they were already used on ships at that time or, thought of how to do it. In fact, the problem had to be how to include them in a ship without affecting its structure and safety. Another drawing of the second volume shows a group of soldiers in a rowing boat whose prow and stern are protected by wooden fenders in the form of castles and various pieces of bronze artillery (if they were made of iron Schilling would have painted them the same color as the soldier's steel armor). The boat has no lidded gunports. Next to this boat is a large bronze bombard arranged on a floating board and with a large and thick piece of wood in its stock to stop the recoil. The display of such a bombard on a ship deck should not be very different. Finally, another drawing from Schilling's *Spiezer*'s chronicle shows a large vessel on the starboard side armed with six bronze cannons, due in this case to the striated decoration of their chases. One is placed in the middle of the aft castle and another in the bow, mounted on a carriage used also in land sieges, with a pointing system in height, which Schilling drew profusely in his works. Four others are located on the side, protruding through holes in the hull. Although they lack lidded gunports, the drawing makes it clear that the guns had already been placed on the sides of the ship, even if it was on the bridge and not on the main deck. The elevation systems drawn by Schilling were used in cannons with vertical appendages in the breeches that allowed them to raise or lower the barrel depending on the shot angle. Many cannons with these appendages have been preserved, including the aforementioned cannons cast for the mayor of Lübeck Johan Herze, recovered from *Engelen* sunk in 1565.

If this type of artillery equipment were made in Switzerland(!) during the last quarter of the fifteenth century (although the events narrated in the chronicles were earlier and occasionally occurred outside the Alps), it is clear that Schilling very well knew warfare techniques, cannon types, combat gun carriages, and how to place artillery in sieges. What these drawings show is that land sieges found some answers that were later transferred to naval combat. If the modifications in naval warfare did not happen earlier it was not due to a delay in the advances in artillery, gun design, the improvement of gunpowder, or in the construction of gun carriages, but because of the impossibility of shipbuilding to incorporate large cannon on board. Powerful large-caliber guns, corned gunpowder, and gun carriages adapted to each type of cannon already existed and were being successfully tested and improved in land battles. Therefore, shipbuilding had to evolve to allow the implementation and development of the advances made in land warfare. This evolution did not happen at the same time in those different parts of the continent, nor at the same speed, and the transmission of the advances would be carried out by shipwright masters, by soldiers trained in the art of war, or by the ships themselves, which linked some ports with others, either being chartered for war or commerce or were captured as booty. Its adaptation to different scenarios should not have been the same either.

For the years in which Schilling illustrated his works, perhaps the gunports should not be common or were widely disseminated. This is demonstrated by the work of John Rous' *Pageant of the Birth, Life, and Death of Richard Beauchamp, Earl of Warwick*, a manuscript with war drawings made in the South of the Low Countries, perhaps Bruges, after 1483 (BL MS. Cotton Julius E IV). The drawings show in great detail the English fighting against the French and Genoese, but no artillery gunports appear on any ship. The only weapons carried by the ships are wrought-iron cannon mounted above the top of the gunwale. Five similar wrought-iron, "*culebrinas de mano,*" probably from the end of the fifteenth century, are preserved in the Museo del Ejército, Toledo (Spain). They have small calibers, one-piece long tillers, no priming pans, and they have no master or workshop marks but each bears initials, probably corresponding to the ships on which they were mounted.

Likewise, Biagio d'Antonio *The Betrothal of Jason and Medea*, ca. 1487, also shows two ships on each side of the Apollo temple where Jason proposes Medea marriage (Fig. 13.3). They are two great three-mast ships with elevated castles of prow and stern. The one on the right, behind Medea, with the stern in view, has a side opening with an open lidded door and the rope or cable which opens and closes it from the chock is clearly visible. The other boat on the left, behind Jason's back, has the opening hidden behind the coast, but it is possible to see the same rope or cable that comes out of the chock of the first deck. It can be deduced that it has another port located in the same place as the ship at the back of Medea. However, the cable is located near the main mast, while the boat on the back of Medea is closer to the stern. This could suggest that there are at least two openings on the side of each ship, which is a big step forward from the previous examples with a single porthole open on its sides.

Another less detailed image appears in the Chronicles of Nuremberg by Hartmann Schedel, an illustrated history of humanity from Creation until 1490. It was printed in Latin (*Liber chronicarum*) and in German (*Die Schedelsche Weltchronik*), by Anton Koberger in Nuremberg in 1493. It included a large number of woodcuts from important cities of the time. The print of the city of Cologne includes the image of a ship with seven openings in the starboard band and although they are not lidded, they could hardly have any other sense than to place a firearm with which to defend themselves.

It is clear that the opening of gunports was a fact closely connected to the opening of the loading/ventilation doors or portholes. Once these were opened, would it

Fig. 13.3 Biagio d'Antonio's The Betrothal of Jason and Medea (attributed), Florence, ca. 1486. Two great three-mast ships with elevated castles at prow and stern. Both have side openings with lidded doors. (Source: Musée des Arts décoratifs, Paris, PE 102, © MAD, Paris)

be possible to make other openings for the artillery at regular intervals on the side of the ships or even at sea level, which could be opened and closed while the ship was sailing, and which were sufficiently watertight? (Barfod, 1990). There is an entry in the documentation of Princess Joanna of Trastamara's voyage to the Low Countries in 1496, which contains an explicit reference to artillery-topped gunboats (*vid infra*). This is one of the first written references. However it is clear that while others should exist, it appears that they have not yet been found or published. There is no doubt that the gunports were a transcendental innovation in the ship's shape, but there were still other modifications to be made such as the gradual elimination of the great inclination of the decks. While a merchant ship could have sloping decks that ascended into the high fore and aft castles, a warship needed more horizontal decks where the artillery could be mounted and handled easily. Thus, the high castles (which stood as homage towers similar to the fortresses), had to gradually reduce their height to avoid complicating the positioning and use of the cannons in them. The stability and firepower of a ship were always detrimental to usable space.

The recoil of the guns produced enormous pressure on the decks and beams but also required more usable space on the deck. In order for the abrupt movement of the cannon backward to be properly contained and the loading operation to be carried out in the shortest possible time, carriages were needed to absorb the recoil and relieve it by means of a complicated set of pulleys and thick ropes that slowed the cannon and quickly returned it to its newly loaded site. This needed a large free space around each cannon in which the gunners could move to handle a varied repertoire of utensils to load and clean the bores. The average time to recharge the piece and return it to its site depended on each situation (the gun, the men, the combat…). The number of cleaning and loading tools was smaller in the case of breech-loading cannon. It was necessary that the gun carriages were adapted to each type of gun and they have to fit in the best possible way to each ship model. Little is known about the shape of the early carriages on board and how they were tied at the end of the fifteenth century and the first half of the sixteenth century, though they should not differ much from land ones. An innovative change in the wheels of the naval carriages was the absence of the metal bands present in most of the land warfare carriages. Such reinforced bands damaged ship decks and for this reason, the embarked carriages did not present this type of reinforcement, as it has been verified in the excavations of the *Lomellina* (*vid infra*) and the *Vasa*.

Ships may have systematically alternated different types of guns depending on their material of construction as a solution to distribute the weight of artillery on decks. The late gothic tapestries of the Parish Museum of Pastrana (Guadalajara, Spain) offer some hint of this alternation. The tapestries consist of two series that narrate the deeds of Alphonse V of Portugal in the campaign in North Africa. The first series narrates the disembarkation, siege, assault of Arzila, and the taking of Tangier occurred between 20 and 29 August 1471 in four large fabrics (11 × 4 mt.) woven around 1475 in Tournai, probably by PaschierGrenier on cartons of the court painter Nuno Gonçalves by order of Alphonse V, who gave them to the Spanish House of Mendoza, whose IV Duke, Rodrigo Díaz de Vivar de Silva Mendoza, donated them to the collegiate church of Pastrana in 1667. The second series, much less known, narrates the capture of Alcazar Seguer in 1458 in two fabrics sewn around 1490 in a workshop in Brabant.

The second tapestry from Alcazar Seguer—Marching from Portugal, crossing, and arrival to Alcazar Seguer—shows a ship whose stern is armed with five cannons (Fig. 13.4). The number is not relevant, but the fact that they are iron and bronze pieces. There is no doubt because the rest of the guns that were represented in the tapestries also make clear the perfect difference with the embroidery of a different color. These pieces placed in the aft castle, called *guardatimones*, fired against an enemy ship that had the intention to disable the rudder. It is evident that cannon alternation of different materials was already used at the end of the fifteenth century. It is also seen in another illumination of the History of Alexander the Great (*Faits du Grand Alexandre*) made around 1470. Later examples of this alternation—such as the *Mary Rose* shows—are nothing but the survival of previous practices. A lidded gunport is visible in the stern of the ship of the siege of Alcazar Seguer, in the starboard band, although without cannon. Presumably, the port side will carry another similar port. These lidded ports located in the stern are also observed in one of the two carracks represented in the *Tavola Strozzi* (Fig. 13.5). The table shows the triumphal entry of the Aragonese fleet in Naples after the victory in Ischia on 7 July 1465, with the galleys in line and two three-mast carracks at the dock picking up their rigging.

Fig. 13.4 Taking of Alcazar Seguer. Second cloth of the capture of Alcazar Seguer. Pastrana tapestries, ca. 1490. Brabant. Museo Parroquial de Tapices, Nuestra Señora de la Asunción de Pastrana, Guadalajara, Spain (detail). Stern of a ship with alternating bronze and wrought-iron artillery (Photograph by author, 2018)

Fig. 13.5 *Tavola Strozzi*, Francesco Roselli (atributted), ca. 1472, Museo Nazionale di San Martino, Naples. Two great carracks at the dock with lidded ports located in the stern. (Source: Ministerio per i Beni e delle attivita' culturali e del Turismo, Polo Museale)

4 Early Examples of Embarked Artillery

Some of the first uses of gunpowder in Europe were recorded during the Hundred Years War in relation to the war in the English Channel (some others occurred during the Spanish Reconquista against the Muslim Nazaries, though these pages are not the appropriate place for their discussion). According to Froissart, it seems that around 1340 Castilian ships fighting in the Hundred Years War carried "culverins," not the long cannon used 200 years later, but long handguns of small caliber. The first documented payment in England for cannon came in 1345, in relation to the Crécy campaign (López Martín 2011). From there, its use begins to generalize. As we have seen in the preceding pages, guns were developed and expanded during the fourteenth and fifteenth centuries and were not used at sea because of the ship's design and construction. The number, weight, and size of the cannon increased as shipbuilding progressed.

The development of the large-scale onboard artillery occurred in two distant geographical areas. The first was the Mediterranean, where the confrontation between the Christian and Muslim powers provided undoubted advances in tactics and weapons. The Naples wars between France and Spain perfected these advances because the logistics and resources employed far exceeded everything seen previously (the Turks armed large fleets but did not have serious opponents until the frontal clash with Spain and her allies). The achievement of these tremendous efforts was due to a coherent foreign policy based on the use of permanent ambassadors and huge financial resources available for both crowns which had not excessive controls by the different estates or city councils. The second geographical area was the Baltic sea, where a political and mercantile war between the Hanseatic League, the Low Countries, and Denmark was fought. The struggle for commercial supremacy led to the construction of large warships and, as in the case of France and Spain, the Danish Crown sought the means to freely use resources and ships. Both the Mediterranean and the Baltic are closed seas with just one access channel, huge natural resources, and continuous struggles for political and commercial interests carried out by the different states. The Indian Ocean, where the Portuguese opened a commercial expansion route to India, was undoubtedly important, but the weapons and ships followed the models developed in Europe since, it was, after all, a transfer to that part of the world of the war fought against the Ottoman armies and fleets in the Mediterranean.

The question of when ships were specifically built for war in the Mediterranean is extraordinarily difficult to answer, but in the Baltic, there were more precise geopolitical conditions that help to establish a tighter chronological clamp for the construction of great warships. It is commonly accepted that large ships—especially large warships—were at the forefront of shipbuilding and design. Large vessels should have been the first to move from the clinker technique to the carvel technique. However, before finally leaving the clinker, probably during the first or second decade of the sixteenth century, both construction techniques were used at the same time in the same ships.

Archaeology has provided two conclusive examples of this alternation in ship construction techniques: the *Gribshunden* and the *Mary Rose*. Both were built in the vicinity of the English Channel and both had carvel-built hulls while their castles were clinker-built. Carvel-built hulls are simpler to build, lighter, and require less caulking, making them cheaper and more flexible. However, when ships were growing in size, the weight of a more complex rig with large sails and long decks prepared to receive large bronze cannon, required hulls capable to support great weights and could successfully guarantee battle platforms adapted to broadside gunnery, besides facing high seas and oceanic winds. The carvel-built technique was more appropriate for these purposes. Where these changes occurred for the first time is difficult to say. The second tapestry from Alcazar Seguer, which represents the crossing to Alcazar Seguer in 1458, shows in great detail a large ship from the stern with a large sterpost formed by an articulated plank with hinges that follows the curved profile of the keel (other rudders in the tapestry are completely straight). The whole hull seems to use the clinker technique whereas the stern castle uses the carvel technique. This tapestry was sewn around 1490 so both techniques were in use in the Low Countries area at the time.

5 The Mediterranean and the Naples Wars

In terms of artillery, it is difficult to establish a fixed number and type of guns arming “Iberian” ships, but rather for “Mediterranean” ships. The Mediterranean was undoubtedly a scenery where hull design, complex rigs, tactics, and weapons for Iberian ships were perfected. The kingdom of Naples and the republics of Venice and Genoa played a key role in the development of great battleships driven by rivalry between themselves and by the Turkish threat. The Naples wars served to perfect logistics, although in the Spanish case, mainly for the crown of Castile, the effort made since the first half of the fourteenth century to gain control of the strait of Gibraltar and keep open communications with Perpignan and Sicily—the great

Spanish naval base in the Mediterranean—at the end of the fifteenth century, it served as the basis for the preparation of the Naples wars. Castile had a powerful merchant fleet on the Cantabrian, Andalusian and Mediterranean coasts. In 1481, Castile had sent a 70 ships fleet to confront the Muslim siege of Otranto. Since 1492 Indies fleets needed continuous planning, more efficient administration, and increasing financial resources. At the same time, the important naval experience of the Crown of Aragon in the Mediterranean since the Middle Ages was indispensable for the Naples wars. Notwithstanding, the human, financial, and warfare resources were defrayed by the Crown of Castile. It is not surprising to find in the recent non-Spanish historiography an almost total absence of the key role played by Castile in the Naples wars. However, the evolution of the attitude of Ferdinand the Catholic from the initial protection of the local branch of his Neapolitan dynasty to the definitive conquest of the kingdom was conditioned both by the availability of Castilian resources and by the different phases of the conquest of Granada (Hernando Sánchez 2015).

Spain and France had extensive lands facing both the Mediterranean and the Atlantic that served as communication channel between the naval technologies that existed in the Levant and the Atlantic façades. Other routes through which technological advancement in shipbuilding could be spread are found in the work of experienced soldiers who fought on both shores and on the ships themselves, which linked one port to another. It seems that political circumstances were a decisive factor for local shipbuilding and the mobility of foreign shipwrights (Zwick 2016). All these conditions occurred in the Mediterranean.

The ultimate consequence of the descend of Charles VIII to Naples in the summer of 1494 was the military occupation of the kingdom, which forced the Catholic Kings to give a naval response to uphold the rights of the legitimate Neapolitan king, Ferdinand II, married to the sister of the Catholic King. Thus began the first war for Naples. What Ferdinand the Catholic was really looking for was the incorporation of the Neapolitan kingdom to the kingdom of Aragon and thus neutralize the French threat to the kingdom of Sicily, whose legitimate king was, precisely, the Catholic King. After the end of the Granada war, the conquest of the kingdom of Naples became the main objective of Spanish foreign policy as a mechanism to isolate France. When at the request of the Catholic Kings, the Holy League of 1495 was formed, Charles VIII was forced to return to France and left the Duke of Montpensier as lieutenant of Naples. The partial withdrawal of the French troops left some losses in punctual land fights, such as Fornovo (6 July), or in sporadic corsair attacks at sea, for example, the capture made by Biscayan and Genoese corsairs of the artillery taken by the French troops on 22 February 1494 at Castel Nuovo "the most beautiful in the world, all copper (bronze)," which had been shipped to France and collected in an anonymous illustrated inventory of the Neapolitan artillery, preserved today at the Louvre (Ladero Quesada 2010; López Martín 2011). The difference between the French artillery and that taken in Naples was probably that the first had advanced austere designs that fired more powerful iron projectiles instead of stone. The fame of the French artillery train had spread so quickly throughout Italy that the fortresses rushed to capitulate one after the other without the French having to fire a single shot. Leonardo da Vinci left a sample of the types of French cannon used by Charles VIII and Louis XII in two drawings made between 1513 and 1515. Several pieces from those series have survived (López Martín 2011).

Spain could not yet fight on equal terms on land with the French army or face Charles VIII's artillery. However, Spain took advantage of the sea. This was the reason for the Catholic Kings to send two fleets in order to prevent the French troops from getting reinforcements. The first fleet, sent in January 1495, was composed of 25 ships—a carrack, seven *naos*, 17 caravels—and a crew of 1873 men under Galcerán de Requesens, Count of Trevento, who had been in command of the fleet in Ischia (the fleet represented in the *Tavola Strozzi*). The second fleet was sent between March and April 1495 and was formed by 25 caravels that transported infantry troops (3450 people) under the command of Gonzalo Fernández de Córdoba, a veteran of the Granada war. Four other Basque ships that sailed in June from La Coruña transported 300 pieces of artillery to the land troops of Fernández de Córdoba and for the Requesens fleet. Once in Naples, 100 pieces were kept for the fortresses defense, while the other 200 were sent to the fleet. Despite the Spanish defeat of Seminara (21 June 1495), Spanish troops entered Naples on 7 July, although Castel Nuovo and Castel dell'Ovo remained in French hands until December. The Duke of Montpensier capitulated on 27 July 1496, thus ending the war and the French presence in Naples.

With the war finished the French corsair actions against the Spanish merchant fleet of Flanders increased. It was the reason for the Catholic Kings to ordered in the autumn of 1495 that the merchant ships be armed with weapons and artillery. However, the official but brittle peace was an uncomfortable situation for Spain, because a month after the French capitulation in Naples, the Catholic Kings were about to send with a great fleet their daughter Princess Joanna (later Queen of Spain and Duchess of Burgundy) to the Low Countries to marry Philip Duke of Burgundy. The fleet had to bring Margaret of Austria—Philip's sister—to Spain to marry Prince John.

To fit the circumstances a large fleet was started to form in August 1495, composed of ships of the Crown and merchant ships adapted for war (Ladero Quesada 2003). This fleet is also an important example of armament embarked. The two largest ships within the fleet were two Genoese carracks hired by don Juan Manuel, the Catholic Kings' ambassador, according to a contract signed on 20 February 1496, having as intermediaries the Genoese factors established in Seville (see Appendix 1). It was planned that the carrack of the Adelantado of Murcia, 760 tons, whose construction was about to end and her rig was going to be installed shortly, would also be within the fleet. Another carrack was built in Ondarroa (Vizcaya). Due to their huge dimensions, carracks were the best ships for transport large shipments, troops, and important retinues. Carracks and great *naos* were preferred by the Catholic Kings and their construction was stimulated with a cash bonus and other advantages to the shipowners, who preferred, however, Basque ships of between 100 and 300 tons and Andalusian caravels of between 60 and 90 tons because they were cheaper to build and maintain, and charter for trade (Ladero Quesada 2010). Armada's supply was made in Andalusia and Galicia. Finally, the fleet was formed by 22 large ships and 20 medium vessels: the two carracks, five caravels, 15 *naos*, and 20 pinnaces. There were no galleys due to their lower capacity to navigate in oceanic waters (although galleys were used on certain occasions through the sixteenth century in the Atlantic). Pinnaces were used for rescue, warnings, disembarking, and towing operations. Coming into the English Channel the pinnaces had to go in order, with the oars and gunpowder arms prepared, scouting the route ahead. Most of the ships came from Guipuzcoa, Vizcaya, and Cadiz, though the fleet departed from Laredo (Cantabria). The crew was formed by 2260 sailors and 2250 men of war. Finally, the total number of people in the fleet rose up to more than 5200 people.

The contract offers important aspects about the rental of large ships. The Crown paid the pilots' salary, and the captains paid nothing since they sailed until they returned, including mooring in ports or any other tax. The captains could carry out actions of privateering—if there was a chance—obtaining the usual percentage, except against ships belonging to the Doge of Genoa, the Duke of Milan, and "his subjects and friends." Employers could carry any merchandise they wanted as long as their weight did not exceed the weight of the ballast they used to carry—stone, pebble, or sand—and that should not interfere with the useful space of the people and beasts they carried. As witness signed Domingo Centurion, a member of the Genoese family of bankers and merchants who had established branches in Italy, Spain, and the Low Countries. Among the activities of this family was the purchase and sale of second-hand ships. The *Victoria*, the only surviving ship of the Magellan expedition that sailed around the world for the first time under the command of Elcano in 1522, was purchased by Esteban, Domingo's brother, in Seville in February 1523.

The Genoese carracks of the fleet had to be "*alterosas de castyllos,*" which means with high castles to prow and stern, 1000 tons and 130 crewmen each. The carracks' names, *Buzol* and *Lerca*, come from their Genoese ship owners, Gregorio de Buzol and Esteban de Lerca. The former sank in front of the sandbanks of the Flemish coast upon the arrival of the Princess in September 1496. The *Lomelllina* (probably also called *Lerca*) in which the Princess went, sailed afterward to the Naples war. The rent of each carrack cost 750 gold ducats per month and was paid 2 months in advance before setting sail from Genoa and another month before setting sail from Cadiz. They had to sail from Genoa to Cadiz without stops, and in addition to the crew, each carrack had to carry a ship's master (i.e., a captain), a pilot, a guardian, a crossbowman, two caulkers, two barbers (i.e., surgeons), four trumpeters, 15 pages, 20 gunners [*lombarderos*] and 40 cabin boys. Other people were officers and sailors. All but the boys must be over 18 years old. Each carrack had to have "its strong and firm bridge or corridor covered with sturdy boards," both above and on the sides, to attack and defend, as was customary in the carracks of war. They had to be protected by pavises—wooden shields that protected from firearms—, bows and crossbows. Each carrack carried 110 crossbows and 100 bombards, each firing 20-pound stone balls. Among them, there should be three "*que tiren sotacubierta con sus conpuertas levadizas.*" This is undoubtedly an early written reference to lidded gunports placed on the main deck under the bridge and firmly establishes that lidded gunports were in use before February 1496, since the contract already requires that the carracks must carry three pieces, each, placed in the first deck, emplaced in lidded gunports. The breech chambers of each bombard had to be able to be used in others of its same type and thus caliber. Any different bombard had to have two or three chambers of its own category. Hence, calibers were regulated and this is standardization. Another clause in the contract says that, if the six bombards that had to be placed "*sotacubierta*" could not be bought in Genoa during the whole month of February, they had to be acquired in Spain.

However, gunports are not represented in Melchione Ferraiolo's *Cronicadella Napoli Aragonese*, written sometime after 1498, *terminus ante quem* of the chronicle. It narrates with drawings the 4 years elapsed between Ferrante I of Aragon's death in 1494 and the entry of Federico I in 1498, thus, between the French invasion and the first Naples war, which Ferraiolo witnessed. The buildings, landscapes, and ports were carefully executed in detail, such as the fleets and the ships—*naos*, carracks, galliots, and galleys—, which appear in numerous scenes. A two pages view of the Gulf of Naples shows the Aragonese ships in the open sea ready to confront the French fleet anchored in front of Castel Nuovo (Fig. 13.6). The largest ship, a carrack seen from the stern, bears Aragonese flags and several ships sails around her, including a large galleass with a cannon mounted in the bow as a "*pieza de crujía*" with the arms of Aragon aft, which it seems to be a later addition as the galleass is incomplete and breaks the perspective on Castle Nuovo. In another scene (f.115r) appear four large ships. The two bigger represent a carrack and a *nao*. The distinction between them is very well appreciated. The carrack is longer and stylized with high castles, especially the forecastle, which presents a great development, and a large sail on the mainmast. The *nao* is more robust and compact and carries a large square sail in the main mast and a Latin sail in the mizzen. It is not the only drawing within the chronicle that both types of boats are represented. A proof that the scenes depicted are trustworthy is a drawing of the French artillery taken to Naples (f.122r) in which there is a wrought-iron bombard next to a large two-orders faceted bronze cannon with plain cascabel, a convex cone, which is piercing to receive a handling ring. The cannon is firing an iron ball. Two guns dated 1488 made for the city of Neuchâtel (Switzerland) along with a life-size drawing, show the same shape. These features confirm the date of the chronicle to the end of the fifteenth century (López Martín 2011).

The odd number of bombardsin the carracks of Princess Joanna, three, is remarkable, except in the case that they could move from one side to another. It is possible that the placement of the three pieces on the main deck was similar to what is seen in a miniature of Jean Colombe's *Faits des Romains*, ca. 1485 where a large warship has two guns located in round gunports without lidded doors. Above there are four unlidded ports cut into clinker planking possibly to place cannon. The same gunports without lidded doors appear in a copy of Olivier de La Marche's *Le chevalier délibér*é, ca. 1500–1516, in which another ship carries six wrought-iron guns over the gunwale and two other looming through almost identical gunports located in the main deck. The reference to Princess Joanna's carracks fits much better to a drawing of a three-volume manuscript copy, 1510, of Enguerrand de Monstrelet's *chronicle*

Fig. 13.6 Melchione Ferraiolo's *Cronica della Napoli Aragonese*, ca. 1498, fol. 116v-117r. A two pages view of the Gulf of Naples shows the Aragonese ships in the open sea ready to confront the French fleet—"*Larmata francesa*"—anchored in front of Castel Nuovo. The largest ship, a carrack seen from the stern, bears Aragonese flags. (Source: The Morgan Library & Museum, New York, Ms. M.801)

which narrates deeds of the Hundred Years' War. The text refers to events that occurred in 1403 between the English and Breton naval forces. However, what really shows is the Franco-Breton fleet (united since the wedding of Charles VIII with Anne of Brittany in 1491) confronting the English, depicting late fifteenth and early sixteenth century ships and artillery (narrating events from the past with scenes from the present is something recurrent to miniaturists). The ships already have a great quantity of artillery located in the castles and the great French ship protagonist of the drawing—possibly another carrack—also has another cannon at the middle of the bridge, leaning over the gunwale and mounted on a two-wheeled carriage. The stern castle has four lidded gunports closed. Another piece appears at the port side on the hull from a lidded gunport (Fig. 13.7). All the pieces seem to be made of bronze because, like the Pastrana tapestries and many other artistic representations, the illuminator painted different materials with different colors. The large piece that appears through the bow gunport has concentric reinforcement rings, but it is not possible to think that it pretends to be a wrought-iron bombard. Bronze pieces also used concentric rings imitating those of large wrought-iron guns in which the rings were functional. The aforementioned Johan Herze's cannon (*vid supra*), have concentric rings on their chases. The fact that the barrel in the drawing has a great length does not have to be an error of the artist (Guérout 2017), since in

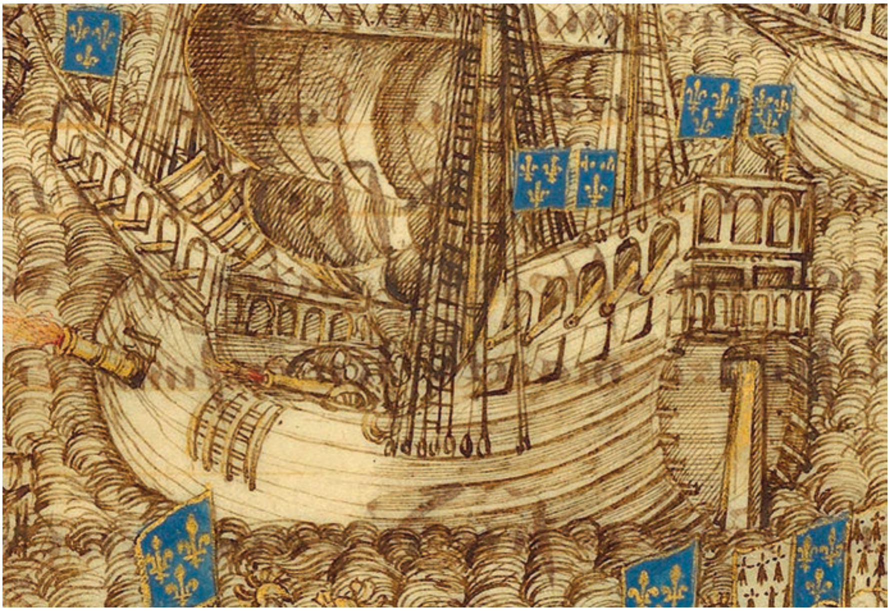

Fig. 13.7 *Chronique d'Enguerrand de Monstrelet, continuée par Mathieu d'Escouchy. Livre I: Années 1380–1432*. BnF, Ms. Français 20,360, 1510, fol. 35r (detail): "Comment Ladmiral de Bretaigne et autres seigneure combatirent les angloys sur la mer et de gilbert de frethun qui fait guerre au roy henry dangleterre." A great battle between the English and Breton naval forces. The carrack is heavily armed with at least 13 guns on the port side, while the stern castle has four lidded gunports closed. The bigger gun sticks out from a lidded gunport and the other is mounted on a wheeled carriage. (Source: gallica.bnf.fr/BnF)

1510, the date of the manuscript, the ship could occasionally assemble a piece of great length or great weight. Two serpentine siege cannons of 350 cm in length dated in 1514 and 1530 were recovered from the wreck of the *Kronan*, sunk in 1676 (López Martín 2011). Each carrack in Princess Joanna's fleet of 1496 also had: 15 arquebuses; 14 quintals of gunpowder (644 kg); 110 crossbows with 40 shots for each one (4400 projectiles, normally lead "*bodoques*"); 120 breastplates and 120 head protections ("*celadas*" or "*capacetes*"); 50 "*tablachinas*" (light shields); 5 quintals of tar (230 kg for caulking); 2000 thorns (stellate iron points to throw to the enemy); 150 spears; and 300 partisans.

The artillery of the fleet, which was made specifically for the ships, consisted of: 6 heavy bombards firing 50 pound stone balls with their chambers, carriages, irons, ropes and nails; 14 bombards of 25 pounds stone balls with three breeches each (42 breeches); 30 bombards of 12 pounds stone balls; 25 bombards of 6 pounds stone balls; 178 bombards of 1 pound stone; 182 "*pasavolantes*" that fire 2 pound iron and 3 pound lead balls, with 3 breeches each (546 chambers) with their carriages; 400 "*espingardas*"; 70 "*sacabuches*"; 10,500 2 pound iron projectiles; 23,446 half pound iron dices (used since the fourteenth century to make the harder projectiles or as shrapnel); 1100 3 pound lead pellets; 1500 lead balls for the "*sacabuches*";

20,000 balls for "*espingardas*"; 75 "*calçadores*" for the "*espingardas*"; 2000 stones for artillery; 2000 blocks for the bombards (to enter the bore before the shot and therefore it is the same amount as the stone projectiles); 230 quintals of gunpowder (10,580 kg), both "thin and for bombards"; and 50 quintals of lead (2300 kg). As bladed arms, they carried: 500 crossbows with 483 pulleys to tighten; 1874 "*carcaxadas*" (carjacs, cases for the crossbows); 220 pairs of cuirasses; 200 helmets ("*capacetes*"); 1000 spears for the cavalry; 3380 hand lances; 916 dozens of hand darts (10,992 darts); 2500 paveses, of which 1300 were large "*de barrera*"—for protection against other ships—and 1200 small ones as personal planks ("*tablachinas*").

This list gives an accurate idea of the weapons carried on board, weapons that were not a technological novelty since they were in use for a long time and are basically the same as those that appear, for example, in the work of Richard Beauchamp, Earl of Warwick. The artillery was forged in the ironworks of Guipuzcoa and Vizcaya and the pieces were tested before being shipped. Gunpowder and lead came from Andalusia, possibly from the arsenal that the Catholic Kings had established in Écija at the end of the Granada War. Nevertheless, the production did not arrive on time to cover the total number of pieces of greater caliber. For this reason, it was ordered to embark all the artillery that had returned from Naples within the fleets of the 1495 campaigns.

To sum up, these figures can be given for the artillery of the Princess fleet: 435 cannon plus the 200 guns from the two carracks make a total of 635 cannon (without "*sacabuches*" and "*espingardas*"). It is possible that the sacabuches were for the 20 pinnaces. With them, the total of pieces rises to 705. With respect to the "*pasavolantes,*" a memorial of 12 August 1497 of the armament of another carrack of the Crown commanded by Juan de Lezcano (also a veteran from the Granada war), quotes 12 "*pasavolantes*" for the prow castle (Ladero Quesada 2010), which offers its location within the carrack. To this firepower, we must add the 400 *espingardas*. It was certainly considerable firepower, although it must be taken into account that it was an escort fleet for the protection of a member of the royal family and not a war fleet.

When the Count of Trevento returned from Sicily in March 1497, Juan de Lezcano was ordered to take command of the royal carrack for trade crossings while the truce with France lasted. The carrack was at the anchor in the port of Cartagena where Lezcano had to hire the crew and embark for Perpignan artillery and 100 quintals of gunpowder. At the same time, two other Genoese carracks were hired. One was the *Fornuela*, 800 tons, which was at Cadiz, to carry 3000 quintals of "*bizcocho*" cake to the fleet in Naples and for which a crew of 250 men was hired. The other was the *Lomellina*, which was at Cartagena together with the royal carrack, and for which a crew of 300 men (crew plus men of war), a captain, and Francisco—or Franco—Lomelin as master, were hired. Two Genoese merchants, Pantaleon Ytalian and Martin Centurion, advanced the money to pay for the *Lomellina*.[1] In September they received payment for having also advanced 3500 ducats to pay

[1] Archivo General de Simancas, Libro 22, Cédulas Cámara de Castilla, f.324.

Fernandez de Córdoba's troops in Naples. The operation had been authorized by Batista Lomelin's bank thanks to a loan from the aforementioned merchant's Centurion and Ytalian. The transactions between these families and the Spanish Crown continue until well advanced the seventeenth century, showing that the links with Genoese banking were strong. When the hiring of the *Fornuela* and the *Lomellina* was closed, the negotiation for renting two other carracks that the ambassador Juan Manuel made in Genoa was suspended. One of these carracks was expected in Valencia, while the other was Rafael Negron's *Negrona*, anchored in Malaga and although "*es navío pesado*—said the Kings—*avemos savido que es elmejor que ay en los mares y muy alteroso*" (Ladero Quesada 2010). Along with these three carracks (the royal carrack, the *Fornuela,* and the *Lomellina*) other ships were hired: two *naos* (one 1000 tons, 100 sailors, 150 men of arms, newly built in Palamós, Gerona); three *naos* from Biscay (300 ton with 180 men each); a caravel (120 tons and 80 men), and two brigantines for mailings and a "balliner." A total of 3500 men embarked on these 12 ships, whose main purpose was to protect merchant traffic from corsair activities, especially French. The renting was for 2 months since they set sail, and Vicente Yáñez Pinzón (the captain of Columbus' *Niña*) was sent to spy on the navy that the Genoese had in the port of Toulon. The plan was that after 2 months the fleet would return to Malaga to victualling and receive new instructions. However, the fleet was sailing until the beginning of December, except the carrack, which in February 1498 was decided she had to go to Pasajes (San Sebastian's main port) to careen, stopping before in Malaga or Jerez for loading wheat for Guipuzcoa (Ladero Quesada 2010).

In Pasajes, a report was requested to know how much it would cost to careen the carrack or if it was preferable to make a new carrack of 1200 tons. The report was signed by several Crown officials, the two pilots of the carrack (Juan Martínez de Lequeitio and Joanot de Iquirizasu); the captain (García López de Arriarán, another veteran of the Granada war), and differently experienced shipwrighters, among them the shipwright of the carrack (García de Arriola) while other were *nao* masters and caulking masters. By the surnames, they were all Basques. The report was signed on board the royal carrack on 11 December 1498. To careen it was first necessary to disassemble the bow and stern castles and reassemble them once the hull was finished. The term to make a new carrack was 10 months and little wood from the original carrack could be used because it was very worn and damaged, as it had been built in 1487—the year in which the English ship *Regent* was built—, and had "sunk" twice in Naples. This reference to her sinking probably means the opening of waterways and not a complete collapse of the ship. It is also reported that a new carrack would last in the Mediterranean four years, without careening, and seven in the "seas of Spain"—the Atlantic—(probably in relation to the sea temperature), and could still withstand another three or four careen during its useful life. The careen would cost 2,539,600 maravedíes, instead of 3,833,900 maravedíes which would cost a new carrack.[2] Thus, carracks were very expensive ships, both their new construction and their maintenance.

[2] AGS, Escribanía Mayor de Rentas, leg.65.

Despite the truce with France and the safe arrival of Princess Joanna to Flanders, the problem of Naples was not over. Between 1499 and 1500 Louis XII, the new French king after the sudden death of his cousin Charles VIII made effective his military control over Milan and Genoa. The Treaty of Chambord-Granada established the partition of Naples between Louis XII and the Catholic Kings, and the war that Venice held against the Turks offered the perfect excuse for the Catholic Kings to have an operative naval force in the Mediterranean to contain the Muslim expansion in North Africa, avoiding attacks on Sicily and Naples. Thus, both the French presence in Milan and the Spanish presence in Naples could be seen as a guarantee of the freedom of Italy against the Turks. In that sense, the idea of a crusade was good enough for both France and Spain. Venice's main objective was to expel the Turkish threat from its trade routes, so it allied with France and Spain pursuing the same end. Even when a crusade was convenient for Christian powers, the collateral objectives were also important or in some cases, paramount. In this scenario, the Franco-Venetian fleet tried the assault on the strategic island of Kefalonia, occupied by the Turks, but the expedition proved a failure. The Venetian fleet sought refuge in Corfu and the French convoy, consisting of seven *naos* and some carracks, returned to Marseille. One of these carracks was the *Charente*. On 5 June 1500, a Spanish fleet sailed under the command of Gonzalo Fernández de Córdoba. It consisted of 55 ships: 26 *naos*, 19 caravels, four "*tafurcas,*" three galleys, and three large carracks: the *Forne* with 115 crewmen, the *Lerca* or *Lomellina* (1000 *toneles*, Princess Joanna's flag-carrack in 1496) with 120 crewmen, and the *Camila*, Fernández de Córdoba's flagship, with 120 crewmen. They embarked almost 8000 people (4182 crewmen) and 326 cannons: 63 made of bronze had been cast in Baza and Malaga and 263 wrought-iron guns were made in Vizcaya and Guipuzcoa. These cannons were added to those already on board the ships and to which had been transferred from Princess Juana's fleet upon their return to Spain.

The armament sent to the ships was different in each case, probably due to the mission that was expected for them, which shows great planning when it comes to assembling the fleet. Only 41 ships out of 55 received weapons and only 32 ships received cannon: the three carracks, 14 caravels, and 15 *naos*. From this, it can be inferred that they already had cannon on board. The number of pieces was also different in each case, regardless of the tonnage. For example, a 275-ton *nao* received 24 pieces of artillery, while another *nao* of 205 tons received only seven. 18 ships (nine ships and nine caravels) received 248 pieces of artillery, a little more than half of the total, either because they had a specific mission, or because they were commanded by high-rank soldiers. A *nao* was used as a powder keg, transporting 235 quintals of gunpowder (10,810 kg). This armament was separate from the one carried by the land troops.

The carracks *Lerca* (or *Lomellina*) and *Forne* only received a pair of bronze cannon each made in Malaga, which means that they were already armed. The *Lerca* (or *Lomellina*) already had 100 bombards (*vid supra*), while flagship *Camila* received: two bronze cannon from Malaga; two "*sanmigueles*" (possibly bronze pieces); five "*ribadoquinesmusquetes*" (bronze, made in Malaga); a "*prínçipe*" (bronze?); a large "*pasavolante*" (made in Villena, Valencia, probably a piece of wrought-iron);

180 paveses; 128 "*tablachinas*"; 138 crossbows; 34 iron harquebuses; 128 iron "*espingardas*"; 9410 iron dices; 1680 "*caxos*" of warehouse with 20 shots each (33,600 shots); 78 gunner's linstocks; 52 dozens of "*gorguces*" (624 short spears); 327 hand spears (for infantry); 176 heavy spears (for cavalry); 373 iron balls; seven quintals of balls for "*espingardas*" (322 kg); 99 lead balls (for the "*prinçipe*"); 600 lead balls for the "*ribadoquines musquetes*" (120 for each one); 60 lead balls for the "*sanmigueles*" (30 for each); and 22 quintals and two *arrobas* of gunpowder (1013 kg). Within the fleet also were carpenters, ax masters, blacksmiths, and gun-founders along with gunners, depending on the campaigns that were carried out. A large number of breastplates, harnesses, armor, cuirass, and mail jackets were purchased in Genoa, Milan, Rome, and Palermo. Others were taken from Spain (Ladero Quesada 2010).

The fleet sailed from Malaga and made stops in Ibiza, Messina, Corfu, Lepanto, and finally Zante (or Zakynthos). At the end of October, the Spanish fleet met in Zante with the Venetian fleet (now Spaniards' ally) under the command of Benedetto Pesaro, composed of 66 ships, mostly galleys, and galleass. The interests of Venice clashed with those of Spain, mainly with those of the crown of Aragon, but the alliance prevented attacks on Italian territories such as the one suffered in Otranto in 1480 (Hernando Sánchez 2015).

It seems that a carrack hired at the service of France and also called *Lomellina*, under the command of Viscount Ruan, René Prent, arrived in Zante with 600 reinforcement men, but she was paid only for 3 months and just remained 20 days to finish the rent, so she retired a few days later. The current state of the research does not allow to know if she is the same ship or a different one with the same name (the three carracks chartered by Spain were paid until 3 July). Future research should determine this fact. It seems that there were some ships with the same name, *Lomellina*. However, it is not possible that many ships from the Lomellin family have the same name during the same years. In 1499 a *Lomellina* and the *Bozella* were in the first assault on Kefalonia transporting reinforcements to the service of France.[3] It is quite possible that this *Lomellina* at the service of France was the same one that was in Cartagena in 1497, which was hired by Spain, and once the Spanish rental was completed, France hired the carrack. The *Camila*, for example, was dismissed by Spain in October 1501 (Ladero Quesada 2010) and it is unknown if she was rented. Little is known about the charter of large ships in the early sixteenth century. The other French carrack that also went to Zante, the *Bozella* or *Buzoque*, was damaged or lost along the way (Ladero Quesada 2010).

The Spanish-Venetian fleet, with about 10,000 men of war, assaulted the island of Kefalonia, which surrendered on 24 December 1500. Gonzalo Fernández de Córdoba gave it to Venice before returning with its fleet to his base in Syracuse (López de Gómara 2000). On 12 February 1501, the French king appointed the Flemish Philippe de Clèves, Lord of Ravestein, captain-general of the French navy of the Levant, and gave him full powers to go on the crusade to reconquer the

[3] Groupe de Recherche en Archéologie Navale http://www.archeonavale.org/lomellina/an/l_8a.html

territories taken by the Turks in Lepanto, Modon, and other Aegean islands. Clèves set out to command a "good, large and powerful army by sea" formed by ships from Normandy, Brittany, and Provence (Contamine 1980). Among those ships was again a *Lomellina*, Clèves' flagship, probably the same one that had anchored in Zante the previous year with the Viscount of Rouen. Clèves was accompanied by noblemen of the great Genoese families as well as other soldiers and knights, for example, John Stuart, Duke of Albany and nephew of the King of Scotland, and Jacques Galliot de Genouillac, seneschal of Armagnac and future captain-general of the artillery of Francis I. There were also two other carracks, the *Charente* and the *Cordelière*.

The *Charente* transported 1200 men (between crewmen and troops) and 200 firearms (between artillery and portable weapons), of which 14 were guns mounted in wheeled carriages and fired cast-iron projectiles (Fernández Duro 1893; Guérout 2012). La *Cordelière*, 600 ton, was a Breton carrack built in 1498 by order of Queen Anne of Brittany. She had about 40 mt. in length and 12 mt. in width. Among other weapons, she carried 16 large-caliber bronze cannons mounted on carriages and 14 bombards. An octagonal bronze falcon (MuseuMilitar, Lisbon, inv.S-1), probably cast at the end of the fifteenth century, has been preserved. At the half of its chase carries the arms of Anne of Brittany surrounded by the lace (*cordelière*) and above the vent-field a fleur-de-Lys. The ear was nailed and opened again. On the upper right side, has the weight chiseled in Roman numerals: *XIIII* quintals and *XXXV* pounds (ca. 660 kg). The cascabel ends in a rectangular appendix to facilitate its attachment to a carriage. Faceted cannon with a similar appendix has also been preserved. It is difficult to think that the Queen herself was free to order the casting of artillery if it were not for the Breton ships, and so with the consent of her husband, either Charles VIII or Louis XII, around 1498.

In June 1501 Clèves' fleet arrived in Genoa to join eight ships of the Republic: four ships, and four galleys (López de Gómara 2000). In July the French had already occupied their part of Naples under the Treaty of Chambord-Granada and the crusade against the Muslims was an excuse to maintain forces in the Mediterranean in case of any eventuality. In August Clèves arrived in Naples to support the land army of Robert Stewart, Lord of D'Aubigny, with four carracks, 10 galleys, 16 great ships, and 5000 men. Finally, in September a young and inexperienced Louis de Armagnac, Duke of Nemours, took over the supreme command of Naples as Viceroy of Louis XII. Lacking Cléves of a defined objective, the Genoese proposed to attack the island of Mytilene (Lesbos), where they met with the Venetians and with the fleet of the Knights of Saint John of Jerusalem. The Turks opposed great resistance and the assault was a failure. The fleet initiated the return but it was dispersed by bad weather and the *Lomellina* looked for refuge in the Greek island of Cythere. A storm pushed her towards the coast and on 25 November she sank with more than 500 men on board. However, the sixteenth-century Spanish historian de Gómara (2000) quotes the *Lomellina* as the *Messina*, referring probably to the same ship. Again, fresh research is needed to clarify these dark spots. Only a few survivors escaped from the wreck, among them Clèves, who was helped by Fernández de Córdoba to return to Genoa with the *Cordelière* and the *Charente*.

Fernández de Córdoba—already known as the Great Captain—had also begun in 1501 the occupation of the part of the kingdom of Naples in accordance with the clauses of the Treaty of Chambord-Granada. However, as some territories had not been well defined in the treaty, the peaceful understanding between France and Spain began to dissolve and by July both crowns were on the verge of breaking. The Catholic Monarchs doubled the military command in the Mediterranean, giving the Grand Captain the supreme command, but respecting Bernal de Vilamarí in the navy, which was under Lezcano's command. The official breaking of peace between Spain and France was declared on 13 September, when Clèves initiated the assault on Mytelene. After the rupture of the truce, Spanish possessions in Naples and Roussillon were threatened by France, while a war of blockades and defense of positions began in Italy, awaiting reinforcements from both sides.

After several decisive campaigns, the victories of the Great Captain allowed him to enter triumphantly in Naples on 16 May 1503. After the fall of Castel Nuovo by the Spanish army on 18 June, the Great Captain sailed from Naples to take Gaeta and finish the war. The Great Captain besieged the city on 1 July. However, the French still had a strong army there, with seven carracks, among them the *Charente* and the *Negrona*, four galleons, more than 20 galleys "and many other hulls." Great Captain's chronicle refers to the huge size of the *Charente* and the *Negrona* "*las mayores que en el agua se habían visto hasta aquella sazón*" (López de Gómara 2000). The *Negrona* was the same carrack that was at anchor in Malaga in 1497, which Spain did not hire because the *Fornuela* and the *Lomellina*were rented instead. It is evident that when Spain did not hire her the carrack was offered to France, or that France required a carrack to rent. The same can be said of the *Lomellina*. New research in ship rental and sale market at the beginning of the sixteenth century is needed.

The *Charente* went every day to attack the Spanish positions, firing a rain of balls when it went forward and repeated the discharges when returning from the stern. The chronicle of the Great Captain does not mention shots from her sides. It is true that the use of broadside gunnery was not yet necessary against a land target, being able to shoot only from the bow and stern, avoiding offering their flanks to enemy fire (Rodger 1996). However, the daily bombardment from a vessel to land positions indicates a certain degree of development in naval combat. To stop these naval skirmishes the Great Captain sent Ramón de Cardona (later viceroy of Naples), Bernal de Vilamarí, and Juan de Lezcano to fight against the carrack with 16 galleys from which they began to shoot the *Charente* from all sides but the carrack started to defend. The chronicle states that "she walked [*i.d.* sailed] among them [the galleys] like a great serpent among greyhounds." The galleys began to settle around the *Charente* and sailed so close to her "that wherever she wagged she wore them [the galleys] hanging from herself" approaching the carrack from everywhere as if the galleys were hunting dogs. Only a lucky windblown managed to disrupt her from the galleys. The attack was not easy since some galleys were lost and others were damaged, but it was worth the effort because the *Charente* never returned to visit the Spanish positions for fear of being captured. This passage shows how to harass and approach large carracks from the galleys.

Gaeta fell on 1 January 1504 together with the French presence in Naples, which for the second time escaping from France. The French capitulated to Fernández de Córdoba who captured all his army, including the *Negrona* and the *Charente*. However, he let the French take all their ships back as a merciful act. The high-ranking officers of the Catholic Kings and the members of the Council of War harshly criticized his decision and begged him not to return the galleys and keep some carracks, possibly those cited, but the Great Captain said that having achieved victory, they had to have mercy on the vanquished (Rodríguez Villa 1908). The *Charente* was lost for unknown reasons after careening in Villefranche in 1504. The *Cordelière* sank on 10 August 1512 fighting against the English *Regent* off the port of Brest. It is another example of the mobility of ships that fought in different scenarios.

The annexation of the Duchy of Brittany to France in 1491, Joanna's departure to Flanders in 1496, and the war in Naples, which ended in 1504, made it clear that a conflict in one part of Europe directly affected the other in political, military, economic and strategic terms. Likewise, that shipbuilding and warfare were not limited to specific and isolated areas, but that they crossed borders spreading knowledge. In the Naples war, large navies were used for operations that lasted for months or even years. A minimum of 150 ships sailing under the banners of the Catholic Kings between 1500 and 1504. In addition to the specific attacks against precise targets, the fleets transported troops, cavalry, and artillery, supported land armies, supplied garrisons, carried out surveillance tasks, and kept food supply corridors open, especially between the coast of Levant and Sicily and Roussillon. France did the same between the Gulf of Lion, the Ligurian sea, and Naples. Ship types—huge carracks (frequently rented to Genoa), galleys, galleass, caravels, fustas, or pinnaces—were conditioned by the type of operation that was going to be carried out.

There is no doubt that these confrontations changed naval combat techniques as well as cannon firing from ships, even when shipboard artillery was not in use. However, it opened the way to specific treaties on war, such as Philippe de Clèves'. He returned to the Low Countries probably in 1506 and wrote a treatise about warfare techniques he had learned (Paviot 1997). *Instruction de toutes manières de guerroyer tant par terre que par mer* was printed in Paris in 1558, but it was probably written around 1506 and amended between 1515 and 1516, hence, when Clèves served the Dukes of Burgundy and Kings of Spain, either Philip I the Fair or his son Charles. He dedicates a section to naval warfare offering details on the cannon placement onboard ships and fully recognizes that the sea war was changing, giving the artillery a fundamental role, as would Machiavelli shortly afterward. According to him, two cannons and a large culverin mounted on a wheeled carriage had to be placed in the middle of the bridge, in the space between the forecastle and the mainmast. Two other large culverins were to be mounted on each side of the mast, near the winch, which had to be fired forward, since "*pour leur grande longueur ne scauriont tourner pour tirer de costé.*" If this is literally accepted, it can be inferred that the ship had no beam enough to allow the recoil of two guns placed in the same location on each side. However, Enguerrand de Monstrelet's chronicle (Fig. 13.7) shows a cannon firing from the side-mounted on a wheeled gun carriage. On the same bridge—Clèves says—there should also be two large cannon on either side of the rudder, to fire back such as chase pieces or "*guardatimones.*" On the main deck smaller artillery was to fire forward, backward, and—again—towards the sides: "*tirant sur le devant et sur le derriere et les costés scellon que vostre navire sera.*" From this statement, it is not possible to know if the guns would be arranged in lidded gunports but, being placed on the main deck, it is clear that they had to have a type of opening and it is possible that Clèves refers to lidded gunports. On the top of the aft castle, "where people are to fight" could be placed falcons on wheels to shoot where necessary, and on the forecastle could be other five or six falcons or light pieces such as harquebuses and hand culverins. Finally, on the tops, another three or four harquebuses with more handguns could be placed. Other reserve weapons should be kept to help where necessary, as well as pikes, halberds, assault axes, bows, crossbows, bolts, darts, javelins, as well as tools for repair and the work of blacksmiths and carpenters. Clèves states that his text is written from experience when he states: "*Et en ay veu aulcunes* (ships) *que pour se mye[ulx] deffen dre avoyent ung pontdespuis le chasteau derriere jusques le chasteau devant, tout couvert comme lesditz chasteaulx pour pouvoyr secourir l'ung l'aultre*," although, he adds, that it is only done in "*grosses nefz ou carracques.*"

The first thing to do if the combat was between two fleets was the sending of two lightships to explore the sea ahead, just like Princess Joanna's pinnaces arriving at the English Channel. At the beginning of the battle, the ships had to regroup and use the artillery when the enemy was within range because it caused great damage. This did not imply the use of artillery on board, but just precise shots to sink the enemy. The experience had taught Clèves that sea-fights were won more in this way than with collision and boarding. Each man had to occupy his combat place on the ship and worry about closing the waterways caused by the artillery or the ramming of enemy ships and being careful to have the wind behind and try to prevent the enemy from cutting the cables that had been thrown to the enemy ship to board it. The experience of Clèves in the Mediterranean becomes clear again when he recommends a mixed fleet formed by galleys and ships since with good weather and calm sea the galleys could shoot to the enemy ships with their pieces close to the waterline, "*à fleur d'eau,*" he says. Galleys were also useful for removing damaged ships from the combat scene (Paviot 1997).

A great ship sank on 15 September 1516 in the bay of Villefranche-sur-mer (France) in a heavy storm. The wreck has been identified with a high probability, though without much historical basis, with a ship also called *Lomellina* (Guérout et al. 1989; Guérout 2017). It was discovered in 1979 and excavated in 1982. Thanks to archaeology, we know more about this ship, which is thought to have been a commercial transport of war material for the Italian campaigns. In the course of the excavations 15 artillery elements have been recovered, e.g., cannon, chambers, carriages, carriage wheels, ammunition, loading tools, 12 molds for ammunition and, 21 barrels of gunpowder (Cazenave de la Roche 2004). Some of the wheels are covered with an iron band which indicates they were made for land campaigns, while others are plain, typical for naval use. The ammunition is made of stone, cast-iron, lead or lead with iron dice inside it. Bullets and shrapnel made to destroy the rigging were also recovered. The artillery pieces found are all wrought-iron breech-loading guns. Some were recovered and others left in situ. However, it is known that the ship was also armed with bronze cannon. Some were recovered by plunderers from Nice after the sinking and others were saved by the Genoese authorities in accordance with the directives sent by the City Council, which considered their recovery as a priority. In 1531 the captain of the castle of Nice rescued another 16 pieces: a bronze cannon that weighed 12 quintals, an iron bombard ["*trompe*"] with a length of ca. 323 cm., a great swivel-gun with iron bullets, six other swivel-guns, and seven big and small iron bombards. Finally, there were about 31 pieces retrieved. Officially the armament of the Genoese ships prior to 1498 consisted of wrought-iron bombards only, but in that year the armament was ordered to be reinforced with bronze pieces (Guérout 2017), presumably following in a similar way to French and Spanish ships. With high probability, the pieces recovered after the shipwreck and in 1531 were those bronze cannons. It is difficult to understand the clause within the contract of Princess Joanna's carracks on the six guns that were to be placed "*sotacubierta*" and that had to be acquired in Genoa, if they were made of wrought-iron since at that time there was that type of cannon available in Italy. However, it makes sense if the weapons were made of bronze, although there is nothing in the clause that clarifies it.

One of the most relevant aspects of the excavation of the *Lomellina* of Villefranche-sur-mer was the finding of two gunports. One was recovered and the other left underwater. The fact of having lidded gunports for artillery identifies the ship as a warship rather than a mere merchant, although it could also be a merchant adapted for war since it is difficult to think that a merchant ship has been provided with lidded gunports. Antonio de Beatis' diary of the trip made by cardinal Luigi of Aragon (from the Neapolitan branch of the Royal house of Aragon) between 1517 and 1518 on his way to meet Charles of Habsburg, refers to a shipwreck in Villefranche-sur-mer in the course of a great storm. Describing the port, Beatis says that "two years ago" a large Genoese ship sank with a large amount of artillery and a crew of about 300 men, who all died. Beatis was even able to see the top of the mainmast sticking out of the water. "The event—says Beatis—was considered by everyone to be a miracle, for the master and crew had long been evil-living pirates" (De Beatis 1979). Again it is difficult to understand that a mere transport had been chartered to a group of mercenaries.

Further news comes from the Milanese humanist Pietro Martired'Anghiera, counselor of the Catholic Kings, who left a superb collection of letters resulting from the relationship he had with different people since his arrival in Spain in 1488. Among these letters are two written on 15 July 1516 and 21 March 1517 from Madrid (Anglería 1957). These letters inform about a crucial incident that helps to determine the identity of the sunken ship in Villefranche-sur-mer on 15 September 1516: in July 1516 three Genoese carracks were at the port of Cartagena (Spain) loading Spanish wool for export. There were three other warships in search of a pirate, a Spaniard, who with a galleon had caused great damage to the Genoese merchants. The pirate was finally captured, but not by the Genoese, but by the Spanish royal fleet commanded by the Catalan Berenguer. Immediately, the Genoese claimed their punishment. Berenguer refused to do so, claiming that Spain would judge him. However, the Genoese demanded it in accordance with the agreement signed with the Spanish Crown. Due to his tenacious and aggressive insistence, Berenguer ordered him to shoot to the Genoese carracks which, indignant by the attack, immediately threw to the water three boats armed with two guns each one that attacked Berenguer's fleet, leaving one galley struck and sinking the other. In reprisal, Berenguer ordered shoot the carracks from the coast and these responded with the discharge of "huge iron projectiles" on Cartagena, managing to tear down the tallest buildings in the city and causing a great commotion among the inhabitants, who saw projectiles of iron and stonefly over their houses. Such terror could not be expected even from the Turks—said Anghiera—who blamed the incident on Berenguer, who deserved no praise for having carried out an undeclared act of war. Immediately after the accident, Berenguer proclaimed an edict condemning to death all Genoese officers in command of the carracks that fired into the city. However, "the fortune was the one in charge of executing the sentence," since shortly after the "armed carracks that carried out the crime were anchored in the port of Villafranca Nicense-" (Villefranche-sur-mer), where unexpectedly a storm which "after shaking them and striking them violently, breaking the anchor moorings and snatching them in a whirlwind, sank them with about three hundred men, both sailors, and soldiers. Not one escaped." When this was known, the Spaniards assured that they would have preferred to impose the punishment "with their own hands better than with those of the Fortune."

Therefore, the ship sunk on 15 September 1516 in Villefranche-sur-mer is one that carried out the bombing of Cartagena before 15 July of that year, the date on which Anghiera sent the letter to his colleague and compatriot Luigi Marliani. The fact that two gunports were recovered from the wreck of the *Lomellina* confirms that she was a warship rather than a simple merchant, although, as demonstrated in this work, the great carracks also carried out transport crossings. The bombing of Cartagena, a port where the Genoese ships anchored assiduously, allows one to correctly interpret Antonio de Beatis' words when he calls the crew of the carrack "evil-living pirates." It can be concluded that the carracks that were in the port of Cartagena and sailed after the bombing of the city, to Villefranche-sur-mer could be the *Fornuela* and the *Lomellina*. In addition, as we have seen, the Genovese carracks used to carry the same crew and men of war. Specifically, the *Fornuela* carried 250 men and the *Lomellina* 300 men. This aims to serve as notes until waiting for more thorough research. The discovery of a gunport placed in situ on the first deck has allowed pointing, according to the characteristics of one of the recovered wrought-iron guns (CN10), to the firing conditions. The frame found in the excavation does not allow the barrel of the gun to protrude enough for the muzzle to go out at the time of the shooting, because the frame reaches the very end of the barrel. This leads to thinking about collateral problems at the time of the shot, especially with the dense cloud of smoke that would enter the ship and the danger of fire if sparks entered. However, it is quite possible that the bronze cannon recovered immediately after the sinking was actually those placed in the gunports instead of the wrought-iron guns found in the archaeological excavations.

From an artillery strict point of view, there was no difference between Mediterranean and Atlantic ships. These increased in size, the rigging was transformed with large sails, decks were widened to accommodate bronze artillery, hulls became robust to support all that heavyweight and ensure successful ocean navigation. For this, the use of the carvel technique became more appropriate. Artillery, however, remained the same for both areas.

6 Fleet Systems, Artillery Ordinances, Navigation Experts, and Ways to Fight

The remains of the oldest vessels found in America to date are the shipwrecks of Highborn Cay, Molasses Reef, and the Padre Island wreck. The latter is the only reliable dated, from the New Spain fleet of 1554. It is possible that these ships, with a powerful variety of weapons of war and with relatively small dimensions, were ships engaged in trade between New Spain and Cuba. Its dimensions did not allow to carry a large number of large guns. The first serious attacks on the Indies trade occurred in 1521 and 1522 in the vicinity of Andalusian and Portuguese coasts. The new war with France begun in 1521 increased the number of corsairs in the North Atlantic and the Caribbean. The attempt to curb their plunder forced the Spanish Crown to protect the merchant fleets with armed ships that regularly patrol the waters near Spain and Portugal, in the area between Cape San Vincent, the Canaries, and the Azores islands. The Caribbean extension between Cuba, Hispaniola, and the Bahamas was the most dangerous area. From the 1520s onwards, it was ordered to sail in a fleet or "*en conserva,*" to offer greater resistance against attacks, as was already done on the route to Flanders. There was no clear difference in ship types used, which were still all merchantmen, armed for combat with cannon cast by the crown, which maintained guns ownership. Guns had to be delivered to the artillery steward at the end of the trip. There were no big rental carracks on the Indies route. The main problem even in such empty waters was that the ships had few guns, which use was impeded by a cargo excess because the purpose of the ships was trade, not war. Spanish galleons were not hunting ships, but merchant transport that had to defend themselves from plunder attacks. This fear of plundering forced the formation in 1522 of the first fleet composed of eight merchant ships and two escort warships (Caballero Juárez 1997; Mira Caballos 2006). In July a series of ordinances relating to the Indies navigation was issued. It established that the 100-ton ships would carry four heavy iron guns and 16 "*pasavolantes,*" eight per band. It was also forbidden for ships to sail alone to America. However, though the ships sailed together, they were not yet subordinated to the single command or a flagship. In 1533 it was decided that the officers of the Casa de la Contratación, together with a group of experts in the navigation to the Indies, would establish rules for safe navigation. The result was the Ordinance of 28 September 1534 in which the officers from the Casa were also ordered to visit the ship about to sail in order to carry out a pre-loading inspection, verifying necessary repairs were made to the hull, which was properly armed and—at least—with the minimum crew required. The guns had to be placed where the visitor indicated on his first visit, before receiving the cargo, according to the *Recopilación de las Leyes de Indias* (1841, p. 46).[4] The cargo, victuals, and merchandise had to be placed on the orlop and main decks, where most of the guns were placed, had to be left clear of bundles to allow free access to the artillery. *Naos* could store cargo under the quarterdeck as long as one free space was left in each band of the bulwark to place a heavy piece of artillery. On the quarterdeck should not go merchandise, nor bundles, nor serons (1841). According to this Ordinance, ships of between 100 and 170 tons had to carry two gunners to serve the following firearms: 20 quintals bronze sacre (920 kg) with 30 balls; a 12 quintals bronze falcon (552 kg) with 50 balls; six great iron pieces with two chambers and 20 iron and stone balls each; 12 iron or bronze swivel-guns, with two chambers and 30 balls each; 12 arquebuses. Ships of between 170 and 220 tons needed four gunners for the following firearms: a 30 quintals bronze half culverin (1380 kg) with 30 balls; a 12 quintals bronze falcon (552 kg) with 50 balls; eight iron bombards with two chambers and 20 iron and stone balls each; 18 iron or bronze swivel-guns, with two servers and 30 balls each; 20 arquebuses. The *nao* between 220 and 270 tons had six gunners for a half culverin of 30–32 quintals, or a cannon of 40–42 quintals (1840–1932 kg); two sacres of 14–20 quintals (644–920 kg) with 30 balls each; a 12 quintals falcon (552 kg) with 50 balls; 10 great bombardas or "*pasamuros,*" four of which had to shoot iron ball; 24 swivel-guns, with two chambers and 30 balls each; and 30 arquebuses.

What emerges from these listings is that in the Carrera de Indias the wrought-iron artillery still prevailed over the bronze, which was only used in the first discharges because of its greater range. However, despite what was stipulated in the Ordinance, it was the merchants themselves who in many cases avoided adequately arming the ships in order to gain extra space for the cargo since their greatest fear was not the pirates or privateers and cannon fire, but the storms against which they could do nothing. The officers ("*visitadores*") from the Casa de la Contratación decided the number and type of arms that the ship should carry based on its tonnage and who should monitor its correct disposal on the decks. In 1534, a second Ordinance stipulated that the artillery should be adequately mounted on its carriages, with tools and the molds for ammunition with iron dices. It also specifies that the ship "should carry the gunports with their hinged doors and hoops to lift them and make them strong inside" (1841). The Ordinance states that gunports use was officially regulated.

A gunport was retrieved in 1979 from the *Warwick*, an armed supply English galleon wrecked in Bermuda in 1619. It had a rectangular shape with measures of 43.2 × 54.6 cm. and 6 cm. in thickness, the same thickness as the first layer of the ship's outer planking. It had a large iron ring on the inboard face to open and close the lid and it hung on two vertical hinges, just as the 1534 Ordinance specifies, which implies that warfare technology was used throughout Europe for a long

[4] Archivo General de Indias, Indiferente General, 1961, leg.3, f.164v-168)

period of time was almost the same. It also had a fitting for a rope on the outboard face, perhaps to secure the lid while open. A gunport lid retrieved from the sixteenth-century wreck off Alderney Island presents similar features (Chíobháin 2011). In fact, these features are visible in Biagiod'Antonio's*The Betrothal of Jason and Medea* (Fig. 13.3).

To date, a cannon cast in Spain (not within Spanish possessions) from the first third of the sixteenth century has not been recovered from a shipwreck. However, the theoretical number of pieces and their arrangement on a ship are known. *Quatri partitu en cosmografíapráctica, y por otro nombre, Espejo de navegantes* was composed ca. 1537 by Alonso de Chaves,[5] cosmographer and senior pilot of the Casa de la Contratación. It is an exceptional nautical treatise unique in its kind that continues the work begun in Alphonse X's *Partidas*, but also informs the number and position of the guns on a ship at a moment of change for tactics and artillery. Like other nautical and military treatises written by Spanish authors, Chaves was jealously kept to avoid spreading valuable knowledge of navigation to America. It has been studied from different points of view, especially those of navigation, cartography, and cosmography, but never from a strict artillery context. Like artillery treaties, Spanish and Portuguese navigation works were the first and most complete writings published almost during the entire sixteenth century. However, during the first half of the century, there were no specific artillery treaties, but they were included in others dealing with fortification or, as in Chaves' case, navigation. All artillery and fortification treaties have in common that they are the result of the experience obtained by the author on the battlefield—such as Clèves' *Instruction*—and were written with the purpose of training the new generations. In the same way, Chaves' work is a compilation of information obtained by him during his trips to America in order to train new pilots of the Casa de Contratación. Therefore the indications on the number of guns to be carried by the commercial vessels and their position within them, as well as the information that it includes on armament, and the way in which a naval battle was to be conducted, also come from Chaves direct experience at sea about 1534.

The second chapter (*De la gente y bastimentos que deve aver en la nao i de las armas i municiones* f.63r) of the third Treaty, deals with the artillery for a 200-ton ship: six thick bombards mounted in carriages, with two chambers and 20 stone balls each; four "*pasamuros*" mounted in carriages,with two chambers and 20 cast-iron balls each; 40 swivel-guns on the gunwale and the castles, with 20 lead balls each and "iron dices inside them"; and 24 harquebuses "at least," and 24 lead balls for each along with their molds to make more bullets. Chaves included incendiary weapons, which used a kind of flammable chemical compounds that were ignited and thrown to the enemy, such as clay jars filled with tar and gunpowder or with soap with oil (to make slip), hollow stick grenades "with their harpoons and feathers to fire and to throw to the sails and burn them," "tubes for artificial fire impregnated with tar, gunpowder or camphor to throw them on and burn the enemy and the

[5] Museo Naval de Madrid, Ms. 9/2791

rigging of their ship," as well as a whole collection of harpoons, "*alacranes*" (twisted hooks) and "*píldoras*" (tow balls) throwed by hand. The ship also had to carry a good assortment of swords and knives, crossbows, spears, scythes used to cut the enemy's rigging, a lot of thorns with quills and blades, stones and darts to throw from the deck and from the topsails, paveses or shields to raise barriers on the rail and topsails, and shields to use them for self-defense "at the time of the fight." These offensive and defensive artifacts were not new and are also already observed in the aforementioned manuscript of the Earl of Warwick. From this point of view, the war was still tied to medieval practices, using the ship as a floating castle.

According to Alonso de Chaves a ship of 200 tons prepared around 1538 for the battle had to carry at least 10 cannons. Six of them had to be large wrought-iron breech-loading bombards with two chambers and stone balls. The other four were also breech-loading guns called "*pasamuros*" but since they used cast-iron ammunition, they should be made of bronze. The 40 swivel-guns fired lead bullets, so they would probably be wrought-iron, and were mounted on spikes that allowed to adjust the aim in height and direction. The total ammunition for them raised up to 800 balls, which makes swivel-guns Chaves' preferred arm for combat. All the balls had to go with iron dice inside them, as already indicated by the Ordinance of 1534 and it has been verified in archaeological excavations. Finally, firearms were completed with 24 shotguns and arquebuses. Even though its number is smaller than that of the swivel-guns, Chaves highlighted the importance of his ammunition reiterating it bluntly: "two dozen balls of lead, and more lead, and more lead." The swivelguns are the most numerous armament of the oldest wrecks found in America. From Highborn Cay 13 swivel-guns were recovered, and 16 from the Molasses Reef wreck. The *Santa Maria de Yciar*, from the Padre Island wrecks, was supposedly armed with 32 swivel-guns. She was the smallest vessel of the 1554 fleet.

For a total of 74 firearms listed for a 200-ton ship, at least six quintals (276 kg) of gunpowder were needed. The gunpowder was on the first deck near the bow and had to be well secured in their barrels. Chaves' experience becomes evident again when he warns that chambers had to load in the orlop deck and once loaded, they had to go up covered and kept off the fire to prevent an accident. Chaves advises to distribute the heavy bombards and "*pasamuros*" in prow, stern, and on the bridge, but adds that a pair of them had to be placed "to the gunports at the sides of the *nao*." Thus, the 10 great pieces should be located two forward, two aft, two at the lowest gunports, and four in the first deck (presumably two on each side). Some of the 40 overlapping swivelguns were mounted by the quarterdeck and the castles. Finally, Chaves defines the gunports, or "*portanones,*" as "windows that are made on the sides near the water where some shots are placed in time of war."[6] Chaves confirms the Ordinance of 1534 on the gunports, emphasizing that since they were close to the waterline, they had to be provided with lids or lifting doors to prevent the free entry of water, otherwise the ship would be flooded and sink easily. This is confirmed by Chaves himself later.

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[6]Alonso de Chaves, ca. 1538 *Quatri partitu en cosmografía práctica*, *Espejo de Navegantes*. Museo Naval de Madrid, Ms. 9/2791, 60r.

The way of conducting a battle between two ships is dealt in the fifth chapter. As soon as a ship was visible, the first thing to do was to open the lidded gunports of the lower deck and place two large bronze pieces in position to engage in long-distance battle, ship to ship. Likewise, some wheeled carriage guns had to be moved from one side to the other, depending on where the enemy was. Afterward, men of war had to "go up to the tops and put more weapons there and have ready to throw darts, stones, grenades and clay jars filled with gunpowder, tar, oil or lime to blind the enemy." The soldiers had to be divided into the bow and stern castles with the muskets ready, while the gunners helped by the assistants had to have ready the guns and place a powder keg covered with wet clothes at the foot of the mainmast. The carpenter and caulker masters also had to be ready to repair a gap in the hull. With all the crew alert and ready, the battle began with the shoot of the largest pieces located in the bow, the side or the stern, depending on whether the ship was on the hunt or pursued by the enemy. The first shot should try to hit the mainmast. If the gunner thought he could not hit the enemy, then he had to aim to the sides, trying that the shots were not high and miss, to not waste ammunition, and secondly to avoid the enemy was emboldened to see that the first and more powerful shots fired by the larger pieces were lost. If, on the contrary, the first shots were successful, then it produced a great fear to the enemy, leading him to think that if by distance and with the first shots they received such damage, the harm when both ships were close would be greater. The pieces located in the orlop deck gunports should only be fired when both boats were side by side, close to each other and had to be fired to the waterline—"*à fleur d'eau*" as Philippe de Clèves says—because even if the ball did not fully pass the hull, "would splinter it and blow the tow through the air and the ship can quickly be flooded there."[7]

In a fleets battle, it was necessary to put ships windward so that the smoke of the discharged artillery blinded the enemy ships. The fleet had to form in a wing, with the larger ships in the center and the lighter ones on the sides of the battle, and try to envelop the enemy. The battle began with the signal of the captain raising a flag or with an artillery signal, and the flagship played a trumpet. After approaching, big caliber guns should be fired and the swivelguns would be used until boarding when incendiary weapons were used against sails and rigging, while the entire crew began to shout at once and trumpets sounded. The sound was a very important part of the fight because the orders were given by wind instruments, but also the dissonant music together with the smoke and the first instant confusion increased the fear and the uncertainty. The Genoese carracks of Princess Joanna carried 16 trumpeters that were dressed in purple velvet and Venetian crimson, and Jean Colombe's *Faits des Romains* shows people playing musical instruments located above the bow and sterncastles while the boarding begins, and the same musicians are shown in Olivier de La Marche's *Le chevalier délibéré*, in the bow and in the top of the mainmast. Trumpeters also appear in the *Tavola Strozzi* in the prows of two of the central galleys, playing long "*añafiles,*" Moorish musical instruments about 80 cm long. This

[7] Chaves, Quatri partitu…., MNM, Ms. 9/2791, 69v and 70r.

type of trumpet, already mentioned in the thirteenth-century Alfonso X's *Partidas*, can be seen in the Pastrana tapestries. Musical instruments have also been recovered from the *Mary Rose*.

It would not be a surprise that Alonso de Chaves had participated in the drafting of the Ordinance of 1534. However, there is no novelty regarding naval warfare. The only novelty implicit in Chaves' text is the express mention of the use of artillery attacking the sides of enemy ships, firing at the waterline, a technique which Philip de Clèves already mentions after his Mediterranean experience. Shooting at the enemy ships when they were side by side, and the movement of wheeled carriage guns from one side to the other shows the absence of broadside gunnery. The only novelty in the conduct of sea war is the little gun increase firing from lidded gunports, no matter the range. The rest of the battle, however, remained closely linked to fifteenth-century practices and it is a remarkable similarity—in strict terms of warfare—to Clèves' text. The archaeological material recovered from the wreck of the *Mary Rose* fits pretty good Chaves' text, highlighting, once again, the veracity of the speech of the cosmographer.

In England, the construction of ships intensified both in number and in size at the end of the fifteenth century. Henry VII consolidated his power through the construction of large ships (Adams 2013). The crown had begun to build with the carvel technique around the 1480s, at the same time with France, the Dutch provinces of the Low Countries, andprobably Spain. Ships such as the *Regent*, the *Henry Grace à Dieu*, the *Sovereign,* or the Scottish *Michael* seem that had no lidded gunports. John Stuart, Duke of Albany and Scottish King's nephew, had been on board the *Lomellina* with Clèves in 1501 and was able to see the technological innovations on war, being able to see great carracks provided with gunports. Henry VIII inherited these great ships from his father and when in 1509 he acceded to the crown began the construction of the *Mary Rose* and the *Peter Pomegranate*. The former was launched in 1511 and in 1535 began the modification to accommodate large cannons. Some of its lidded gunports were new since dendrochronological analysis of one of the ports in the midship area provides a *terminus ante quem* of 1541, so at least some of the gunports were cut and provided with lids sometime after her construction (Hildred 2005). As it has been seen, the opening oflidded gunports had to be necessarily related to the ship structure and its capacity to withstand an increase in the weight of its artillery, so the original construction of 1511 could not have contemplated a large number of cannons in lidded gunports on its sides. The artillery retrieved from the *Mary Rose* does not correspond to pieces of the early sixteenth century, but are the result of the evolution occurred in gun manufacture during the first quarter of the sixteenth century. As a result of the wreck excavation it is known that the 14 largest cannons were positioned alternately in the main deck, in lidded gunports. This reflects the diversity and gun alternation, but it is something that is already observed in the Pastrana tapestries of 1471–1490.

The joint study of the pieces of the *Mary Rose* and Chaves' text allows observing the number of pieces that carried large warships and how little the type of armament had changed during the first quarter of the sixteenth century. Combat between ships or between fleets had not varied much during most of the century. It is true that the number of guns increased and their use from lidded gunports became common, but the use of shipboard gunnery was not yet in use. Even when artillery had the potential to penetrate with great precision the ship hull, artillery was not used profusely for ship-to-ship distance fighting. It was preferable to wait until the enemy was nearby to unload a great rain of shots, bullets and incendiary weapons before boarding. Cannon, as a weapon of war, had the ability to destroy and even sink an enemy ship in the same way that it demolished the fortresses in the land sieges. Perhaps existed an inability to understand a new form of war at sea. Nevertheless, it is necessary to stress that the main pursuit of the enemy was the booty and they needed to board and capture the ship fighting with a sword in hand to get it. It was a catastrophe if the ship sank.

In barely 20 years, the armament remained basically the same: wrought-iron cannon alternated with other of bronze, two technologies supposedly opposed in the sense of antiquity and modernity, since it has been thought that bronze cannon were the main cause of the disappearance of wrought-iron guns. Despite its fundamental importance, the point is not in the use of both types of guns, since both were effective in combat—albeit with differences in loading speed, range, and penetration—but in the use of the manufacturing technology. The question was to decide between a technology that followed an artisanal method, which shaped the iron manually by hammering in the forge, and another that quickly allowed the casting of identical pieces by the use of molds. However, this method was more expensive due to the complexity of the process, the number of people involved, and the progressive price increase. In the meantime, bronze casting cannon was safer and had greater range, power, and precision. When this process could be cheapened, the cast-iron artillery could finally arm the ships with an endless number of pieces manufactured cheaply and quickly.

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